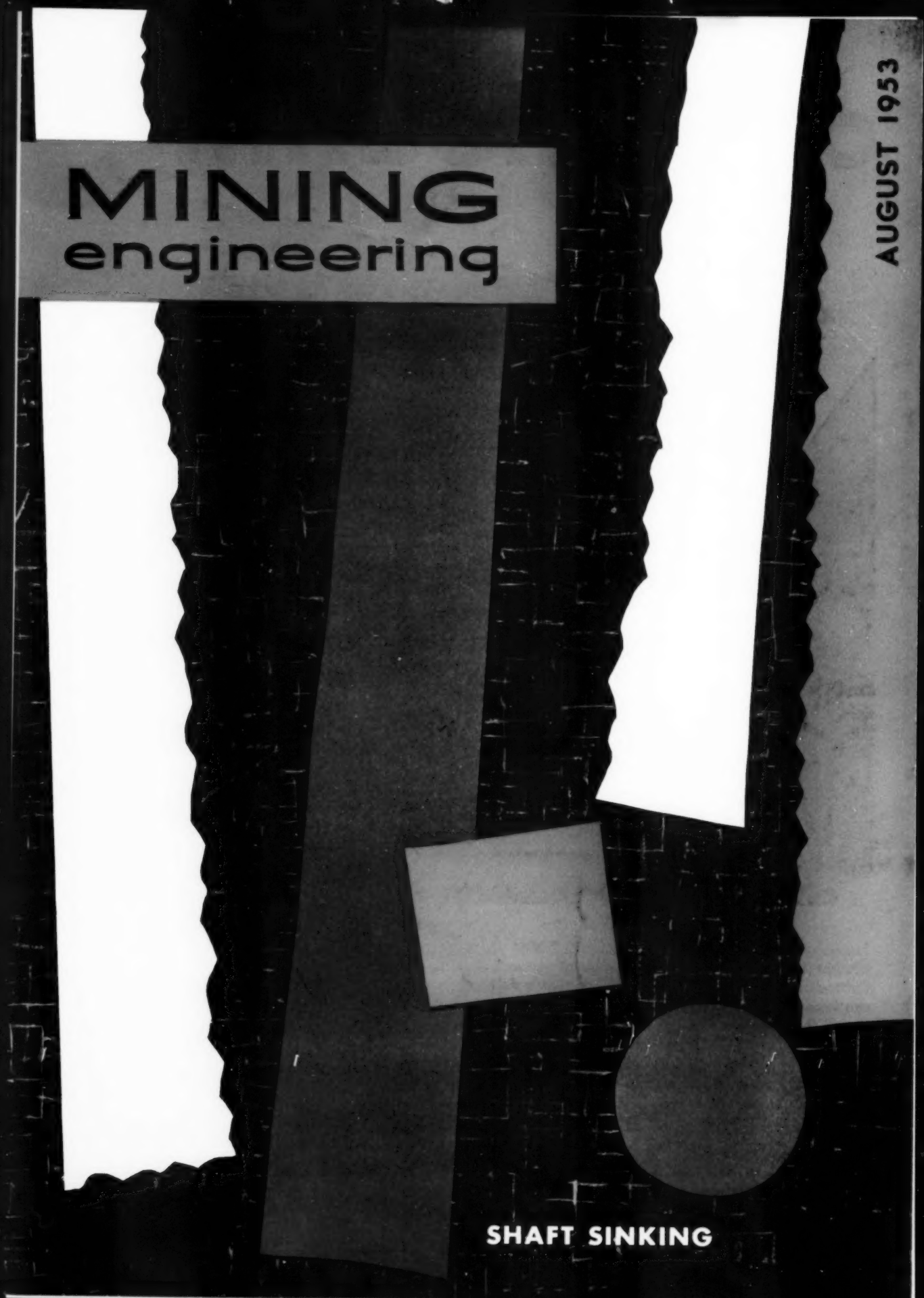
MINING engineering

AUGUST 1953

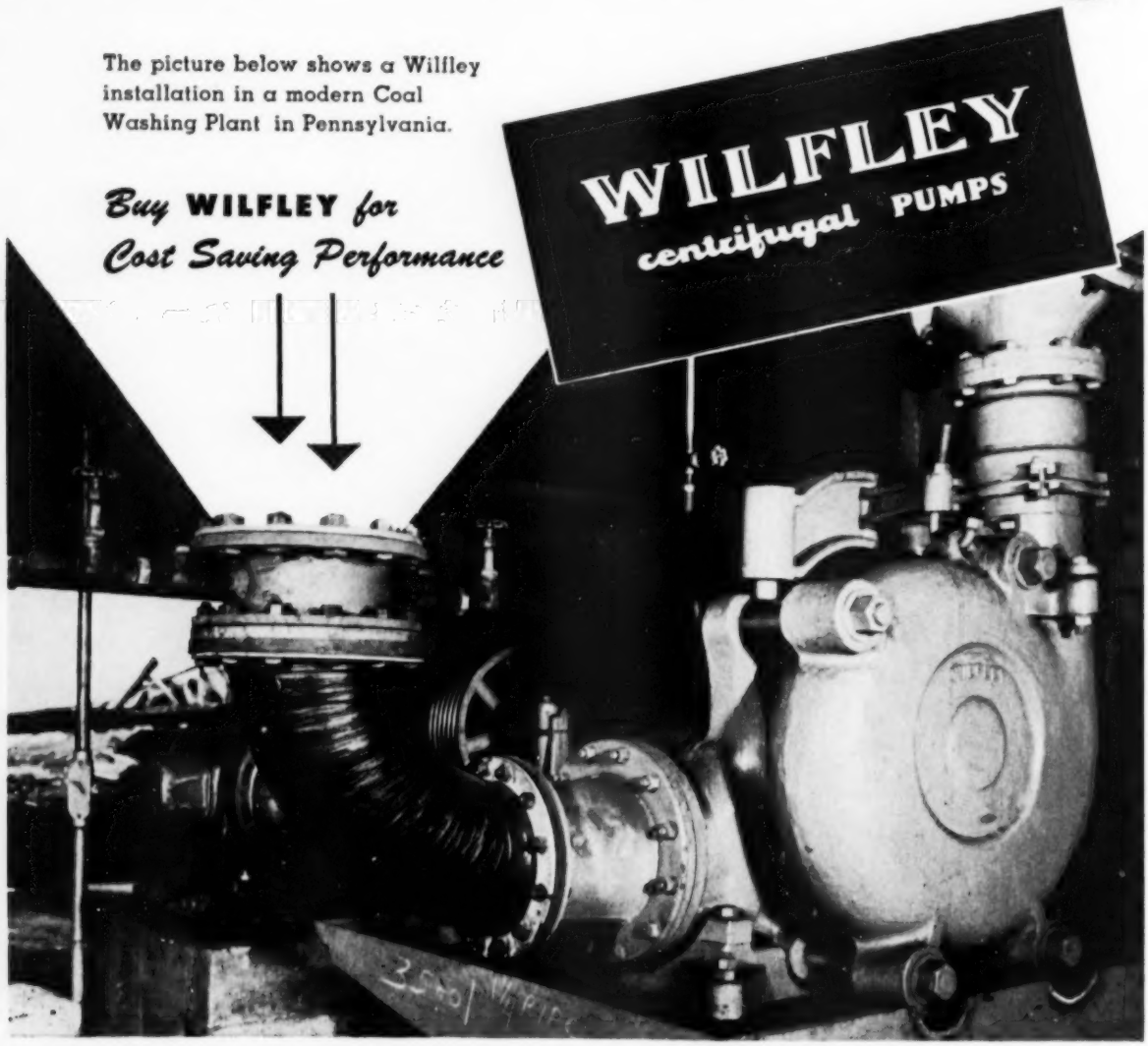


SHAFT SINKING

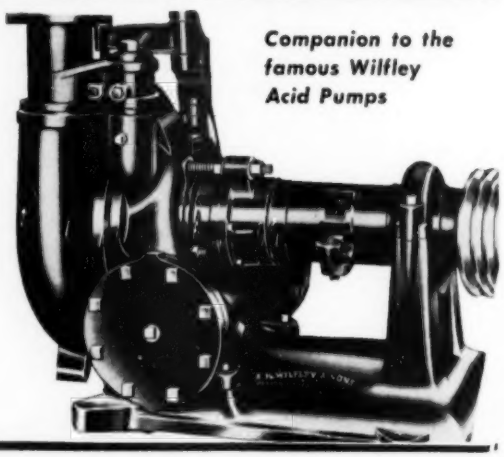
coal cleaning

The picture below shows a Wilfley installation in a modern Coal Washing Plant in Pennsylvania.

Buy **WILFLEY** *for Cost Saving Performance*



In coal washing operations Wilfley Sand Pumps always turn in a notably efficient and economical performance. These rugged, dependable pumps deliver continuous, trouble-free performance on a 'round-the-clock schedule—make measurable savings in operating and maintenance costs. Individual engineering on every application. Write or wire for complete details.



Companion to the famous Wilfley Acid Pumps

A. R. WILFLEY & SONS, Inc.
DENVER, COLORADO, U.S.A.
NEW YORK OFFICE: 1775 BROADWAY, NEW YORK CITY

MINING engineering

VOL. 5 NO. 8 AUGUST, 1953

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COVER

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— Personnel Service —

THE following employment items are made available to AIME members on a nonprofit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Graduate Mining Engineer, 29, married, two children. Five years experience geological exploration, mine engineering, practical underground mining in U. S. and Canada. Desires employment in exploration, engineering, or production in Canada or U. S. Available reasonable notice. Now employed. M-33.

Superintendent, citizen of The Netherlands, mechanical engineer, married. Sixteen years experience design, construction, operation of tin and tungsten concentrators and heavy medium plant. Varied experience in mechanical field. Fluent Spanish. Desires position Latin America. M-32.

Mexican Mining Engineer, 42, married, three children. Eighteen years experience in engineering, safety and mining. Some experience in diamond drilling. Actually a mine foreman. Writes and speaks English. M-34.

POSITIONS OPEN

Resident Manager, Superintendent, and Mining Engineer for an asbestos project now operating on a small scale in Venezuela. Should be experienced in the asbestos business, for company expanding the mining and milling facilities and the camp generally. Y8180.

Junior Geologist, preferably with 2 to 3 years mining experience for lead zinc property. Spanish desirable. Salary open. High altitude. Location, Peru. Y8856.

General Superintendent, 30 to 40, for two quarry operations in fluxing limestone. Should be experienced in both underground and open pit mining, and the handling and supervising of men. Salary plus bonus. Location, East. Y8824.

Chief Engineer to head an engineering department. Must have excellent administrative ability. A broad practical background of experience in flotation and nonmetallic minerals beneficiation is important. Bulk of mining is open pit work with shovel, draglines, bulldozers, trucks, etc. Milling includes both wet and dry operations. Salary, $10,000 a year depending on experience. Location, Texas. Y8821.

Mining Engineer, young, graduate, with some experience in surveying and mapping. Should be able to assume responsibility and get along well with associates. Duties will include mine and surface surveying and mapping, calculating and performing other related engineering work. Start, $4200 a year with opportunities of advancement and salary increase. Location, South. Y8371.

Engineers. (a) Junior Mining Engineer, 25-30, recent mining or geologist graduate, with some training or experience in surveying. Duties will include surface and mine surveying, drafting, map work and general engineering duties connected with underground operations. Salary open. (b) Mill Superintendent, 30-40, graduate, with degree in mining engineering or mineral dressing, familiar with the processing of magnetite. Salary open. Location, New Jersey. Y8930.

Engineers. (a) Superintendent for graphite mine in Mexico. Executive ability and fluent Spanish essential. Give training, experience, and date available. Salary, commensurate with ability. (b) Mining Engineer titled and registered in accordance with Mexican law. Duties not limited to engineering. Excellent opportunity to gain operating experience. Location, Mexico. F-8573.

Mining Engineers, (2) young, with college background and one or two years experience or at least summer vacation experience working in mines. Bulk of mining is open pit with shovels, draglines, bulldozers, trucks, etc. Milling includes both wet and dry operations. Machinery used includes coarse and fine crushing machinery, jigs, ball mills and Raymond mills; vibrating screens, classifiers, dewaterers, thickeners, centrifuges and flotation machines, etc. Starting salary, $4500 a year. Location, one for Arkansas and the other for Missouri. Y7888.

Assayer to take charge of large laboratory. Should have had five to ten years experience in the assaying of precious metals. Salary open. Northern New Jersey. Y7929S.

Junior Geologist who has had some field experience during summer vacations or one year after graduation, for large mining company. Salary $3600 a year to start. Location, Central America. Y7589(b).

Engineers. (a) Sr. Chemist-Metallurgist, graduate, experienced in development work on hydrometallurgy, extractive metallurgy and preferably mineral dressing also. Technical training and experience required. Must have ability to plan and carry out research and development work relating to recovery of metals from nonferrous ores. Salary open. (b) Analyst, experienced in assaying of ores and metallurgical products, particularly pertaining to base metals. Duties will be analysis of test products in research laboratory. Mostly wet methods used. Salary open. Headquarters, California. S-218.

Mining Engineer, young, graduate, with some educational background and/or experience in geology. Must be able to assume responsibilities in connection with an exploratory and prospecting program for the acquisition of ore reserves, as well as to carry to completion general operational engineering work relating to mining and processing of phosphate. Must be available by September 1 or earlier. Starting salary $4200 a year. Location, South. Y8929.

CHIEF ENGINEER. A mature engineer with administrative ability and a broad practical background of experience in construction, plant design, mechanics and cost estimation, to assume charge of Engineering Department. Experience in flotation and non-metallic minerals beneficiation is desirable. The scope of the work covers producing mines and plants in the western and southern states.

Please address replies to:

PERSONNEL MANAGER
BAROID SALES DIVISION
NATIONAL LEAD COMPANY
P. O. BOX 1675
HOUSTON, TEXAS

ASSISTANT MANAGER. American citizen, diplomatic, tactful, 42-48 years, for large going foreign copper operation in healthy, temperate, low altitude area. Must have had good underground mining experience and be a thoroughly competent mining engineer. Some open-cut experience is desirable. Salary open. 3-year contract. Submit complete record, references. Photograph optional.

Box G 14 AIME
29 W. 39 St., N.Y. 18, N.Y.

WANTED

Recent graduate mining engineer or surveyor for work in underground mine. Starting salary $4200, plus overtime pay. North Central United States.

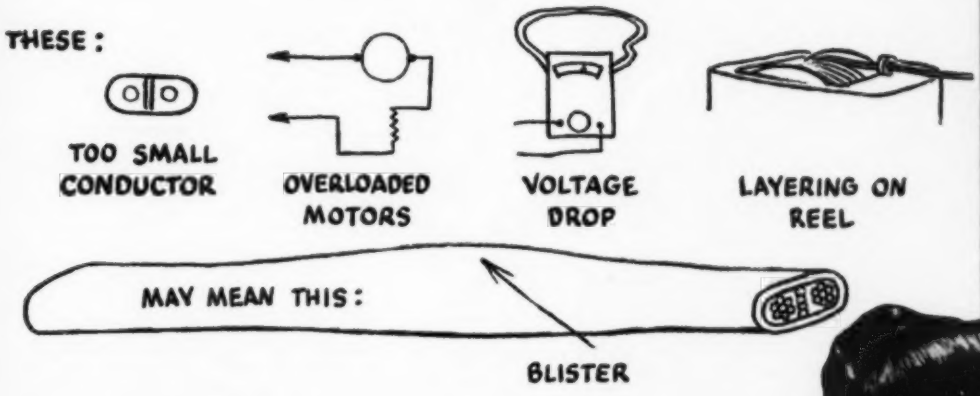
Box G-13 AIME 29 W. 39 St., N.Y. 18, N.Y.

POSITIONS OPEN

A Geologist and a Metallurgist: Married men between 30 and 40 years of age with about ten years experience preferred. Three-year contract. For details, submit experience resume and personal data to:

Mr. R. H. Willey, General Superintendent Philippine Iron Mines, Inc., Larap Jose Panganiban, Camarines Norte, Philippine Islands

HOW TO SPOT DAMAGE FROM CURRENT OVERLOAD . . .



. . . AND WHY THERE'S GREATER HEAT STAMINA IN ANACONDA'S NEW MINING MACHINE CABLE

Blisters, formed by gases from overheated installation, are a sure sign of cable overloading. A torn cable may result. Since you can't always control overloads, it's important to choose *quality* cable.

Today, due to better design, jackets and insulation, good cables shouldn't cook on the reel the way they used to. But this only makes overloads harder to detect. They still may be present . . . caused by too small a conductor, overloaded machines, voltage drop or even layering of the cable. With 4 layers on the reel, according to I.P.C.E.A., unventilated bottom layers lose 65% of capacity.

WHY THE NEW ANACONDA CABLES ARE SAFER

First, they are more flame-resistant. Jacket is made from a new neoprene formula. Improved cold-rubber insulation gives greater heat stamina. Patented breaker strip* insures a safer ground. No ANACONDA Cable has ever failed a U. S. Bureau of Mines flame-test!

CABLE LIFE NOW MUCH LONGER

In 15 mines recently surveyed, ANACONDA Cables on shuttle cars are lasting up to 300% longer than cables made only a few years ago. Together, jacket and insulation protect these cables better—especially in wet mines where sliver-cuts can cause shocks. The cables are tougher. New-type stranding flexes better under tension.

All this means economy because *one* break in cheap cable costs more than you can save by buying on price. For a sample of this new cable, call your Anaconda Sales Office or Distributor. *Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.* 58068

ANACONDA®

TODAY'S HEADQUARTERS FOR MINE CABLE

*U. S. Patent No. 2,455,775

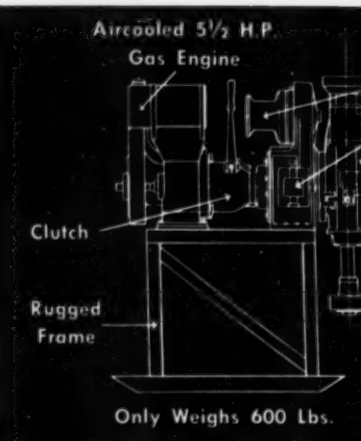
FLAT-TWIN CABLES FOR:
shuttle cars
contiguous miners
loaders cutters
drill trucks

HI-VOLT CABLES FOR:
mine power

TYPE SH-D FOR:
shovels

TYPE SO FOR:
hand drills
remote control

TROLLEY WIRE
FEEDER CABLES
TELEPHONE WIRE
SHOT FIRE CORD
WELDING CABLES

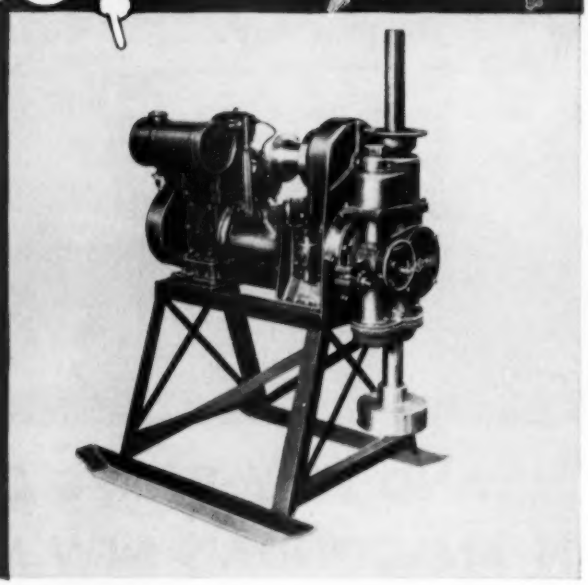


Longyear

PROSPECTOR DIAMOND CORE DRILL

Light Core Drill Powered by Gasoline for Holes Up to 600' in Depth

THE CHOICE OF DRILL OPERATORS FOR DEPENDABILITY AND ECONOMY



Engineering Advancements Assure Outstanding Performance

Cores Tell The Story...

Longyear Prospector Core Drills are built for long, economical and trouble-free service. The gasoline driven Prospector is designed for drilling from surface and is ideally suited for sinking shallow standpipe, and for core drilling after bed rock is reached. Drills can be mounted on truck, trailer or jeep. Industrially, this model may be used in testing foundation sites for bridges, dams and power installations. Prospector Drills are also available in electric and air driven models. Write today and let us tell you how we can best serve your needs.

Longyear

DIAMOND CORE DRILLS • CONTRACT CORE DRILLING
SHAFT SINKING • GEOLOGICAL INVESTIGATIONS

THIS GIANT 60 x 109 gyratory crusher now being built in Allis-Chalmers shops will be capable of crushing 3500 tons of low grade iron ore an hour!

It is one of many contributions made since Allis-Chalmers first started the development of equipment for processing taconite ore . . . in the laboratory . . . in the pilot plant . . . and in actual operations on the iron range.

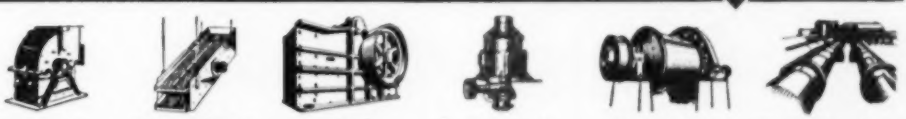
Other metallic ore producers, too, have looked to Allis-Chalmers, *world's most experienced manufacturer of processing equipment,* for crushers, grinding mills, screens and smelting machinery. Allis-Chalmers leadership assures you of equipment recommendations backed by *unsurpassed* experience in all phases of processing.

You'll find the A-C representative in your area a helpful consultant on your processing problems. Call him, or write Allis-Chalmers, Milwaukee 1, Wisconsin, for more facts.

A-3998

ALLIS-CHALMERS

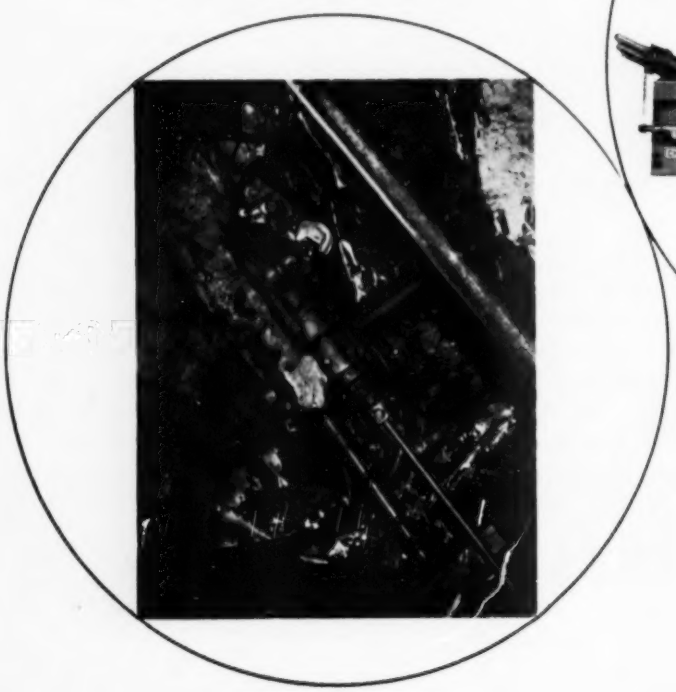
Sales Offices in Principal Cities in the U. S. A. Distributors Throughout the World.

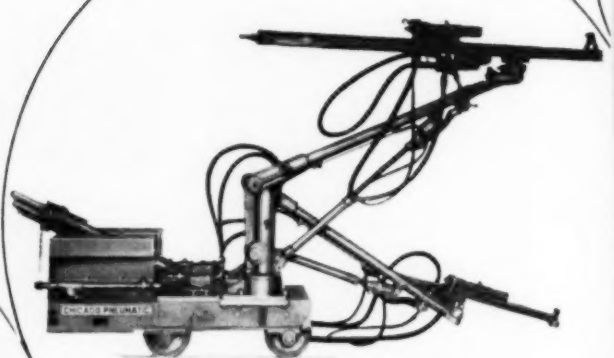


Hammermills | Vibrating Screens | Jaw Crushers | Gyratory Crushers | Grinding Mills | Kilns, Coolers, Dryers

IT TAKES ALL KINDS OF DRILLS

For Faster Drilling – Designed both for blast hole and exploratory drilling, the air-driven CP No. 55 DIAMOND CORE DRILL has the most powerful vane-type air motor built into a diamond drill. Conservatively rated at 500 feet with E Rods and EX Fittings.





G-600 DRILL JUMBO with two typical drill mountings. The upper arm is equipped with a 6-foot Chain Type Feed; lower arm carries a 4-foot Shell Type Feed.

For Faster Tunnel Driving – The G-600 AIR ACTUATED DRILL JUMBO is rail mounted for standard track gauges and furnished in single and multi-boom units. Ideal when teamed with the CP-50N DRIFTER.

TO WORK A MINE!

← **For Stoping or Raising** – The well-balanced CP-34 STOPER has just the right piston speed, foot-pound blow, rotating speed and feed-leg pressure to insure long service from tungsten-carbide bits.
Has a ratchet-type twist throttle on the holding handle, for exceptionally fine control of feed-leg pressure.

↑ **For Top Performance** – The complete line of CP SINKER DRILLS ranges from the CP-22 (28-pound) to the CP-50N (102-pound) class. And – the CP-32 or CP-59 combined with the rugged CP AIRLEG mounting make a real team. The AIRLEG provides rigid, well-balanced support to effectively absorb all recoil.

. . . and whether it be for exploratory,
underground or open pit drilling there's a Chicago
Pneumatic drill for every type of mining.

And they all bear the familiar CP Trade Mark

– for 50 years a symbol that has spelled out high
quality and economy to thousands of satisfied customers.

For more details, write *Chicago Pneumatic Tool Company,*
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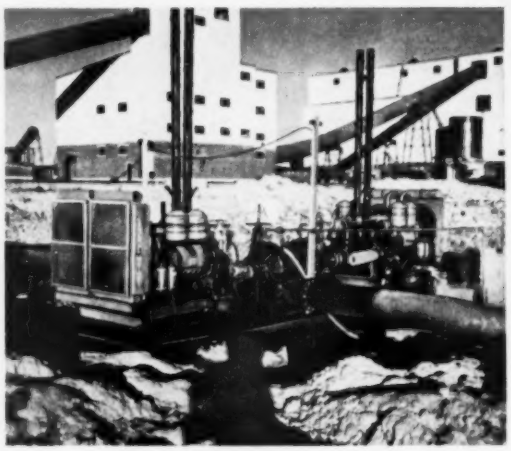
GM DIESEL
CASE HISTORY No. 524-1

USER: Barvue Mines, Ltd., Barraute, Quebec. Hydraulic Superintendent, Bert Thomas.

INSTALLATION: Six GM Series 71 Diesel Twins; two drive 2-stage centrifugal pump supplying three 2-inch monitors which jet the water at 125 psi; two on 12-inch pump pumping water from La Flamme River, and two on 12-inch removal pump which sends slurry (25 to 35% solids) to tailing pit.

PERFORMANCE: Company is hydraulic-stripping about 1,000,000 yards of clay overburden for about 35¢ a yard. Barvue Mines estimated $1.25 a yard to strip by ordinary methods.



SAVED:

$.90 PER YARD ON ONE-MILLION-YARD STRIPPING JOB

Here's a unique application that *proves the profit* of General Motors Diesel power.

Superintendent Thomas reports that the six GM Diesel Twins powering the pumps in this hydraulic stripping operation are on the job 24 hours a day, 7 days a week, except for a 2-hour stop on Saturdays to change oil and filters.

Because of their 2-cycle operation (power at *every* piston downstroke) GM Diesels deliver the steady, uniform power required to keep a steady pressure at the monitors. They burn a minimum of low-cost Diesel fuel. Compactness and light weight make them easy to move. And in remote locations like this, standardization of design means a lot, because a small stock of low-cost parts protects all twelve engines. For dependable Diesel power *at the lowest cost per horsepower hour*, see your GM Diesel distributor today.

DETROIT DIESEL ENGINE DIVISION
GENERAL MOTORS, DETROIT 28, MICHIGAN
Single Engines 16 to 275 H.P. Multiple Units Up to 840 H.P.

It pays to STANDARDIZE on

GM
GENERAL MOTORS
DIESEL POWER

Makes *Cyclone Performance* Better than Ever for Desliming and Classifying

Heyl & Patterson Cyclone Thickener Equipment . . . well known and accepted for efficient, low-cost thickening, classifying, clarifying and desliming . . . now has expanded limits of performance, with the new Heyl & Patterson "Jet-Injection" Cyclone.

In "Jet-Injection" operations, water is forced into the Cyclone at a definite rate and under controlled pressure. This results in a sharper and a more accurate classification of the slurry provided the installation is properly engineered and "Jet-Injection" correctly applied.

During desliming or classifying operations, objectionable slimes that formerly reported to the underflow of the Cyclone with the "wanted" materials can now be removed in the overflow with "Jet-Injection."

HOW YOU BENEFIT FROM THE HEYL & PATTERSON CYCLONE RESEARCH PROGRAM

Heyl & Patterson Research Engineers have conducted numerous laboratory and field experiments to determine the various applications of Cyclones on both ferrous and nonferrous milling circuits. Typical Cyclone applications are: desliming ahead of froth cells; classification for preparation of classified feeds; and in closed circuits with ball mills.

It will pay you to call on the vast experience and know-how of Heyl & Patterson to help you with your desliming or classifying problem. Heyl & Patterson's complete laboratory facilities are available to test the performance of the "Jet-Injection" Cyclone on your product.

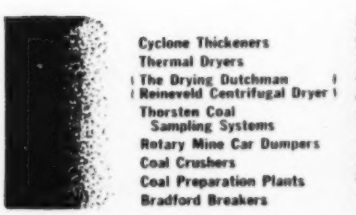
EXAMPLE OF "JET-INJECTION" PERFORMANCE

PROBLEM: Classify a slurry having 10% solids concentration by weight containing 30% minus 200 mesh (minus 74 microns) material with a Heyl & Patterson Cyclone.

RESULTS WITHOUT "JET-INJECTION": Recovered product contained 8% minus 200 mesh material.

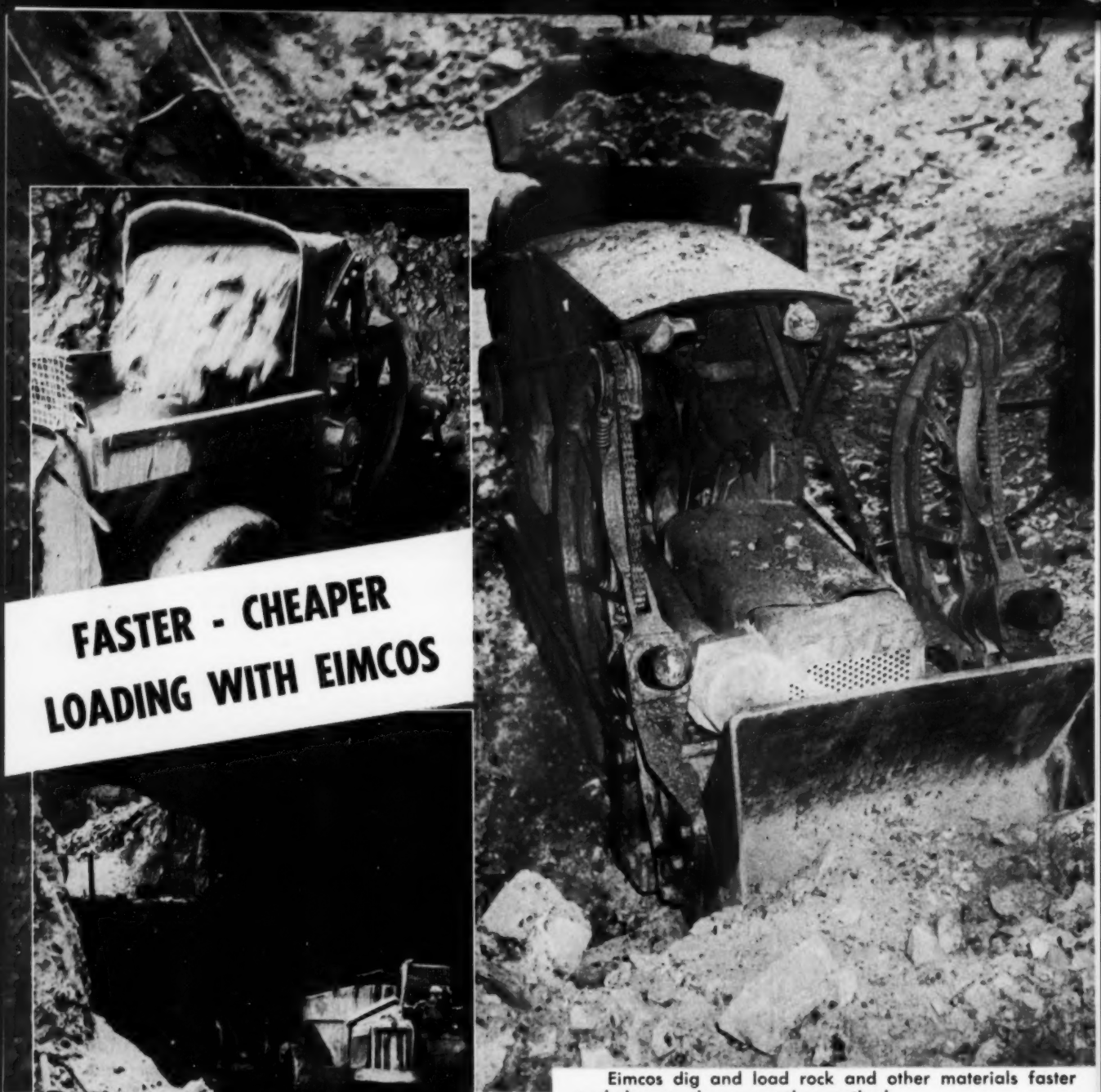
RESULTS WITH "JET-INJECTION": Recovered product contained 4% minus 200 mesh material.

For more information on "Jet-Injection", write for Booklet CT-31.

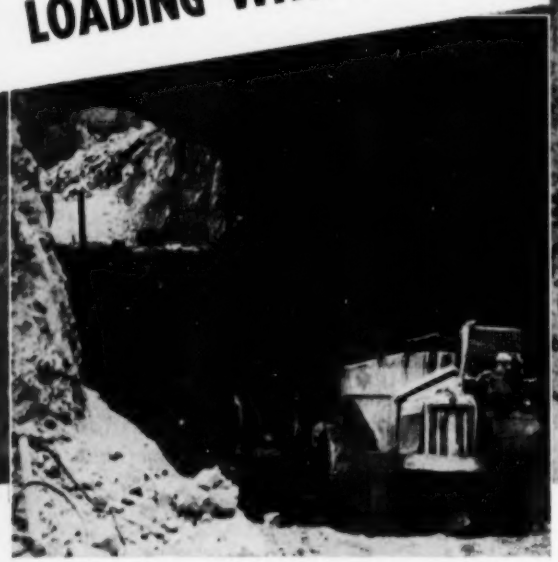


Cyclone Thickeners
Thermal Dryers
(The Drying Dutchman)
(Reineveld Centrifugal Dryer)
Thorsten Coal Sampling Systems
Rotary Mine Car Dumpers
Coal Crushers
Coal Preparation Plants
Bradford Breakers

Heyl & Patterson, Inc.
"SINCE 1887"
55 FORT PITT BLVD. PITTSBURGH 22, PA.



FASTER - CHEAPER LOADING WITH EIMCOS



Eimcos dig and load rock and other materials faster and cheaper than any other method.

In the illustrations above a short division tunnel is being driven on the bench method with one Eimco 104 tractor loader doing all the loading. This has been a good job for the contractor because of the low cost loading performance of his Eimco loader.

For rugged dependability in loading equipment on any size job see your Eimco representative first.

Write for literature on Eimco loaders.

You can't beat an Eimco

EIMCO A460

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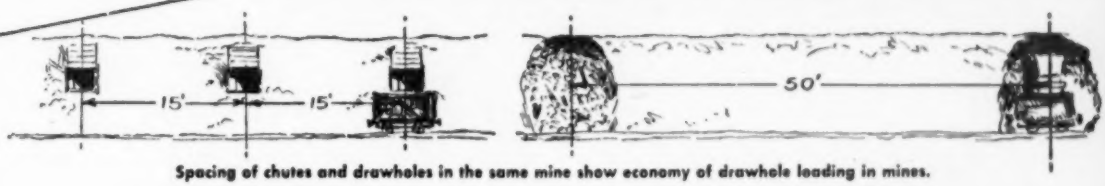
LOWER COST BY LOADING MECHANICALLY



Spacing of chutes and drawholes in the same mine show economy of drawhole loading in mines.

Loading from draw points with mechanical loaders is being used more and more in the development of ore bodies because it has so many advantages. It's cheaper, faster and safer than the chute and grizzly system.

One of the most important differences is the elimination of the grizzly level entirely and the wider spacing of draw points without sacrifice in control of drawing the ore.

Bulletin L1017 shows cost figures on several different operations where chute and grizzly system have been changed over to draw point loading with Eimco loaders. Your copy will be sent on request.

EIMCO A469

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The World's Largest Manufacturers of Underground Rock Loading Machines

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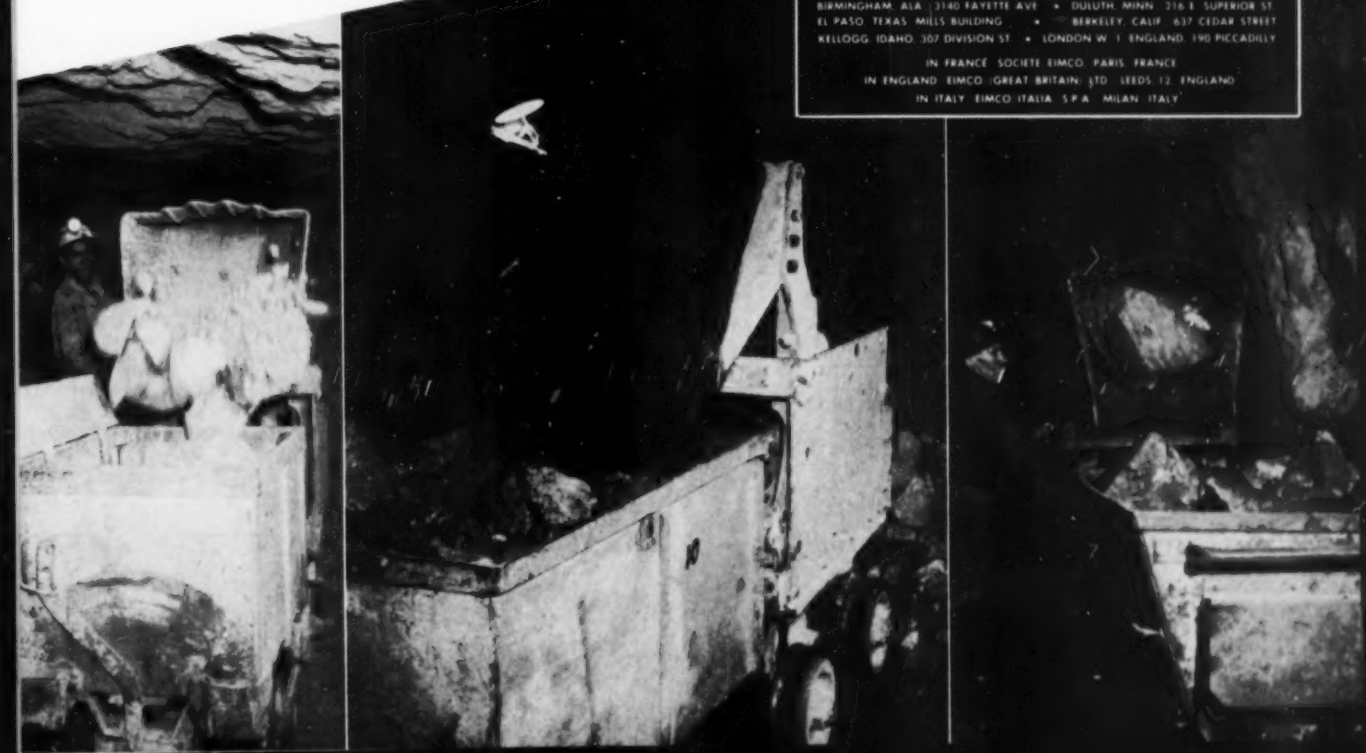

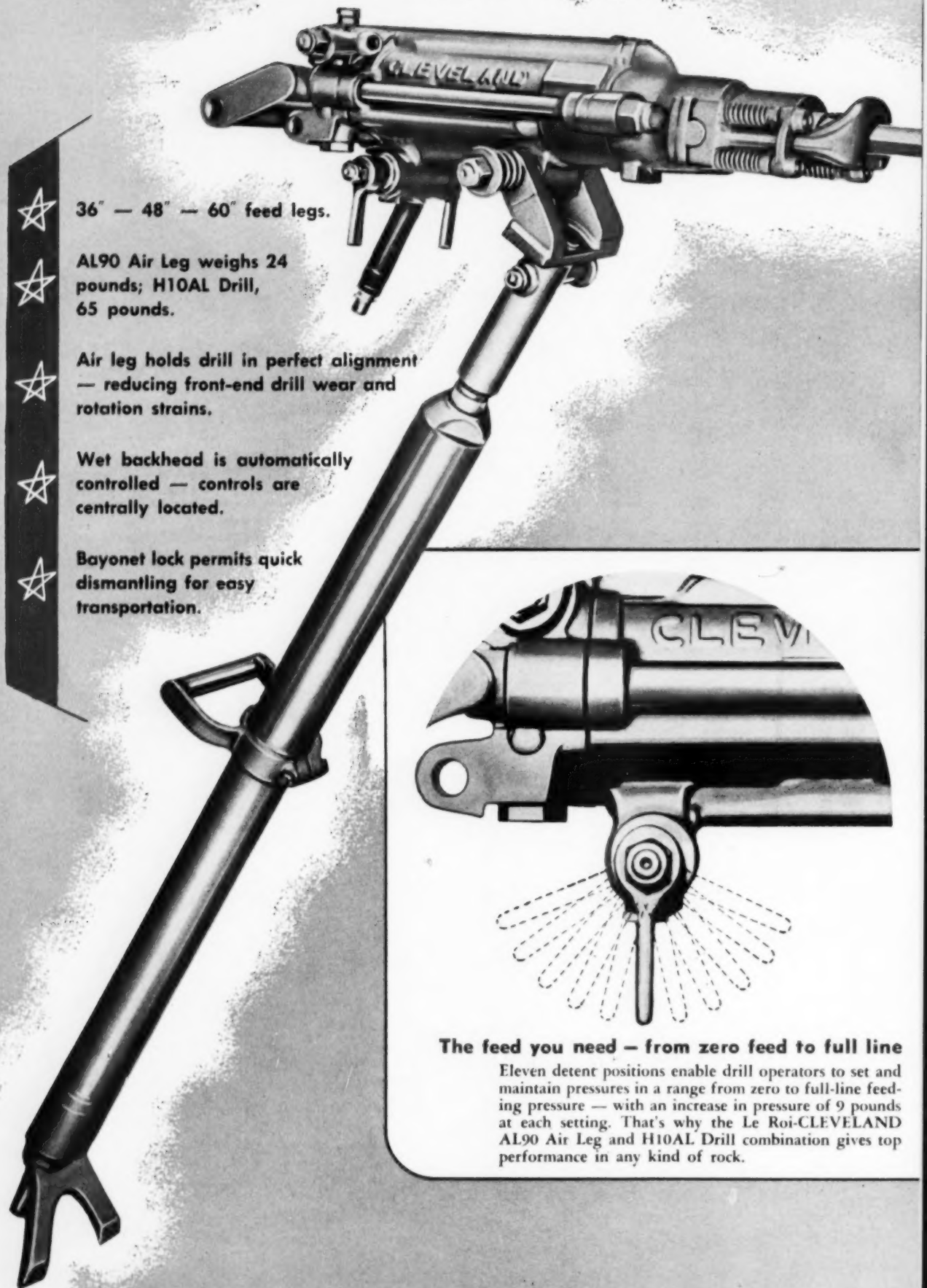

- 36" — 48" — 60" feed legs.
- AL90 Air Leg weighs 24 pounds; H10AL Drill, 65 pounds.
- Air leg holds drill in perfect alignment — reducing front-end drill wear and rotation strains.
- Wet backhead is automatically controlled — controls are centrally located.
- Bayonet lock permits quick dismantling for easy transportation.

The feed you need — from zero feed to full line

Eleven detent positions enable drill operators to set and maintain pressures in a range from zero to full-line feeding pressure — with an increase in pressure of 9 pounds at each setting. That's why the Le Roi-CLEVELAND AL90 Air Leg and H10AL Drill combination gives top performance in any kind of rock.

You're ahead 3 ways:

1. Easier Drilling
2. Greater Footage
3. Lower Costs

— with LeRoi-CLEVELAND AL90 Air Leg and H10AL Drill

And exclusive feed control!

TALK about a cost-cutter — this is it! It's the lightweight Le Roi-CLEVELAND Air Leg.

Let your miners use it with the Le Roi-CLEVELAND H10AL Drill and, mister, they do any underground drilling job easier and faster. They can use this air leg and drill combination *as a stoper* — they can use it *as a drifter* — they can use it *as a sinker.*

It's a tool miners like to use. The air leg not only supports the drill, but also provides feeding pressure. And the leg absorbs any recoil. Miners' work is easier; they are less tired at end of the shift.

But that's not all! The feed control is built in — eliminates the necessity for a third hose and cumbersome "Y" connections. There's no feed-control bleed valve — the operator does not have to continually bleed-off air, to maintain suitable feeding pressure. He can change or advance the position of the leg easily and quickly.

Increase your footage — lower your drilling costs — ease the load on your men. Put the versatile Le Roi-CLEVELAND AL90 Air Leg and H10AL Drill to work for you. Write today for complete information.

RD-51

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LE ROI COMPANY

A Subsidiary of Westinghouse Air Brake Co.

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Plants: Milwaukee, Cleveland and Greenwich, Ohio

Books for Engineers

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Manual on Industrial Water (Special Technical Publication No. 148) *American Society for Testing Materials*, $4.25, 336 pp., 1953.—This book discusses uses of water and problems of supply; composition, sampling, and analysis of industrial water; water-formed deposits; and the reaction and corrosion products of water. The appendix contains all ASTM water standards and test methods. A reference manual.

Concrete Mix Design (Melbourne Technical College Research Bulletin No. 2) by L. Boyd Mercer, *Melbourne Technical College Press*, Melbourne. Approx. 60¢, 59 pp., 1953.—From the standpoint of practical application, this paper deals with the best use of "badly graded" materials, influence of water-cement ratio, and a number of other variable factors such as quality of water, temperature, and mixing.

Air Pollution Abatement Manual, Chapter 12—Bibliography, Appendix 2, compiled by George F. Jenkins and edited by C. A. Gosline, *Manufacturing Chemists' Association Inc.*, 246 Woodward Bldg., Washington 5, D. C., 35¢, 20 pp., July, 1953.—This is the second semi-annual supplement. Loose-leaf forms enable these pages to be arranged with preceding references. The originally-issued Chapter 12 Bibliography is 50¢. A subscription to Appendices for a 3-year period is $1.50.

Housing and Building in Hot-Humid and Hot-Dry Climates, *Building Research Advisory Board, National Research Council*, Washington 25, D. C., $6.00, 150 pp.—This is the complete report on the conference held November, 1952. It contains 17 papers by leading specialists in the field of building for hot climates. Panel discussions and questions and comments from the audience are included. Graphs, tables, over 130 illustrations.

Physical Chemistry of Melts, *Institution of Mining & Metallurgy*. Approx. $2.15, 106 pp.—This volume contains the papers and discussion that formed the Symposium on Molten Slags and Salts held by the Nuffield Research Group in Extractive Metallurgy on Feb. 20, 1952, in London. Included are six papers on recent European research on slags.

Pompes, Ventilateurs, Compresseurs by A. de Kovats and G. Desmur, *Dunod*, Paris. Approx. $11.00, 336 pp., 1953.—This treatise contains detailed considerations of the design and construction of pumps, blowers, and compressors, both centrifugal and axial. In French.

English Rock Terms by W. J. Arkell and S. I. Tomkeieff. *Oxford University Press*, $4.25, 139 pp., 1953.—A glossary of such words as tharf, doab, sloom, and clunch used in the British Isles by miners and quarrymen. References supplied with these names, uncontaminated by Greek and Latin roots, provide a historical perspective. Classified Index.

Geology of the Silver Reef (Harrisburg) Mining District, Washington County, Utah by Paul Dean Proctor, *University of Utah*, $2.00, 169 pp., 1953.—Bulletin 44 of the Utah Geological and Mineralogical Survey is described as "the latest and most comprehensive treatment of this world famous occurrence of silver in sandstone."

Uranium-Vanadium Deposits of the Thompsons Area, Grand County, Utah. With Emphasis on the Origin of Carnotite Ores by Wm. Lee Stokes. *University of Utah*, $1.00, 51 pp., 1951.—Of interest to students of fissionable materials, Bulletin 46 is by the author of the *Guidebook to the Geology of Utah—1948*.

Geological Investigations of Chromite in California, Bulletin 134, Part II—Coast Ranges, Chapter 2, Chromite Deposits of the Southern Coast Ranges of California by George W. Walker and Allan B. Griggs. *California Department of Natural Resources*, 75¢, 50 pp. With photographs, tables, eight maps in pocket.

Geology of the Saltdale Quadrangle, California by T. W. Dibblee, Jr. and **Mineral Deposits of Saltdale Quadrangle** by T. W. Dibblee, Jr. and T. E. Gay, Jr. *California Department of Natural Resources*, $2.00, 66 pp. With photographs, tables, three maps in pocket. Bulletin 160.

Mining Tips and Gadgets by Jack Spalding. *Mining Publications Ltd.*, London, approx. $1.40, 114 pp., 1953.—A selection of mechanical devices, ingenious methods, and practices the author has seen in successful operation in 30 years of mining in various countries. Illustrated.

Refractory Hard Metals by Dr. Paul Schwarzkopf and Dr. Richard Kieffer, *Macmillan*, $10.00, 447 pp., 1953.—This volume deals with the structure, preparation, and properties of the pure carbides, borides, nitrides, and silicides. Bibliographical footnotes are included.

Mining Machinery, third edition, by Thomas Bryson. *Sir Isaac Pitman & Sons, Ltd.* $4.97, 508 pp., 1952.—Originally written as a treatise on generation, transmission and utilization of power, the book has been expanded to include other aspects of mine plant.

Physical Chemistry of Copper Smelting by R. W. Ruddle. *Institution of Mining & Metallurgy*. Approx. $3.00, 156 pp., 1953.—This short monograph on copper smelting from a physical-chemical viewpoint serves as a bridge between industrial practice and current research. Included are tables of thermodynamic data and a review chapter on chemical thermodynamics.

U. S. Bureau of Mines Publications

RI 4940 Gasification of lignite in a commercial-scale pilot plant.

RI 4945 Beneficiating Great Gossan lead ores, Carrol Cty., Va.

RI 4946 Anthracite Mechanical mining investigations, Progress Report 9: Measurement of loads borne by underground-roadway supports.

RI 4949 Pebble stoves for heating gases to high temperature.

RI 4950 Hermada antimony deposit, Elmore Cty., Idaho.

RI 4951 Ore-dressing tests of Aroostook Cty., Maine, manganese ores.

RI 4952 Preliminary tests of Nevada oxidized copper ores.

Request free publications from:
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U. S. Geological Survey Publications

PP 248A Mica deposits of the southeastern Piedmont, pt. 1, General Features. $1.25.

PP 248B Pt. 2, Amelia district, Virginia. 60¢.

PP 248C Pt. 3, Ridgeway-Sandy Ridge district, North Carolina and Virginia: pt. 4, Outlying deposits in Virginia. $1.75.

PP 248D Pt. 5, Shelby-Hickory district, North Carolina; pt. 6, Outlying deposits in North Carolina. $1.25.

PP 248E Pt. 7, Hartwell district, Georgia and South Carolina; pt. 8, Outlying deposits in South Carolina. 50¢.

PP 248F Pt. 9, Thomaston-Barnesville district, Georgia; pt. 10, Outlying deposits in Georgia. $1.50.

Bull 982-B Geology and coal deposits in part of Coos Bay coal field, Oregon. 60¢.

Bull 989-A Geology of Buldir Island, Alaska. 25¢.

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Circ 226 Lignite resources of North Dakota.

Circ 236 Radiometric reconnaissance parts of the northwestern San Juan Mts., Colo.

Circ 239 Uranium deposits of the Bulloch claims, Kane Cty., Utah.

Circ 244 Reconnaissance for radioactive deposits in vicinity of Cape Nome, Alaska.

Circ 245 Geology and pegmatites of part of Fourmile area, Custer Cty., S.D.

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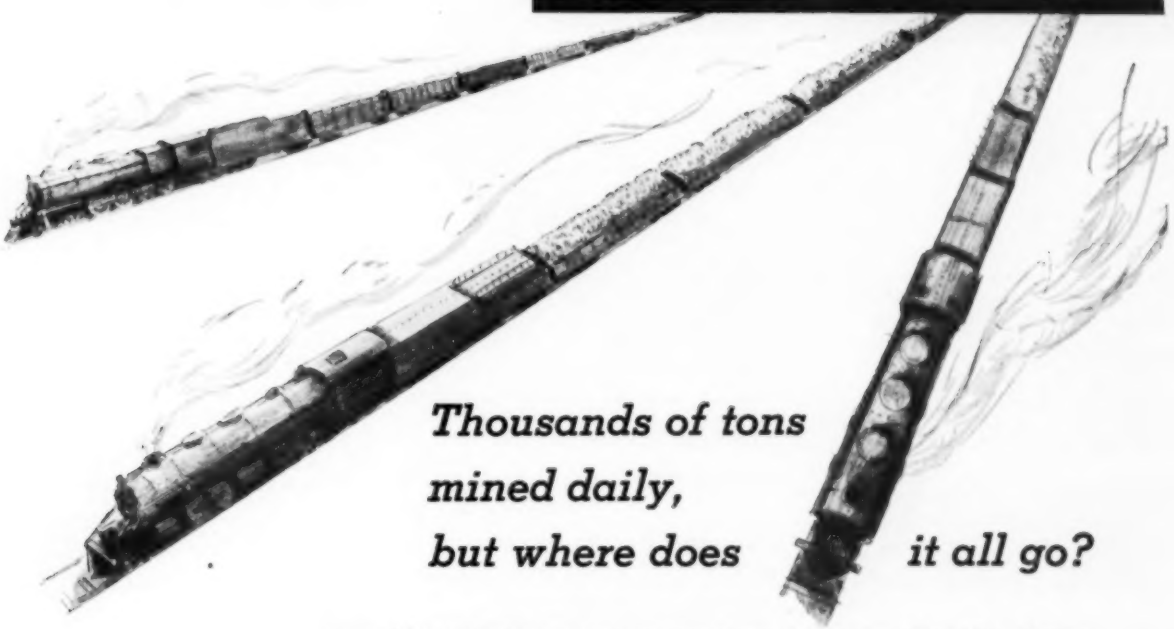
Sulphur



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Manufacturers News

New Products • FILL OUT THE POSTCARD FOR MORE INFORMATION • Equipment

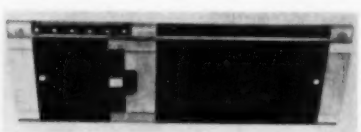
Underground Truck

With a 275 hp diesel in a 60-in. high, 33,700-lb chassis, *Dart Truck Co.* calls its recently announced model the highest horsepower rated truck ever used underground. A torque converter and reversible

transmission provide speeds up to 30 mph in either direction. An apron-type conveyor in the bottom of the body unloads the truck at up to 60 fpm. Hydraulic steering, air brakes, excellent visibility, dual controls handled from a swivelling driver's seat improve driver comfort and efficiency of operation. Engine exhaust passes through a scrubber. First of the 20-ton trucks are destined for a fleet at White Pine Copper Mines in northern Michigan. **Circle No. 1**

GraphAnalogue

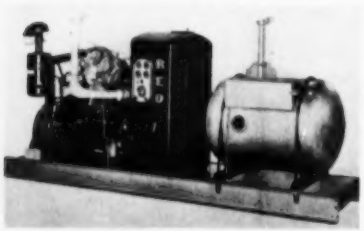
Gerber Scientific Instrument Co. announces a new device with 18 infinitely variable scales. Linear and reciprocal scales with inch, foot, and



centimeter dimensions have applications for plotting contours and elevation, for rivet spacing, reading aerial photographs, and can also handle linear and arbitrary non-linear functions. **Circle No. 2**

Industrial Engines

Reo Motors Inc. is entering the industrial power plant field with a line of 6-cylinder, 4-cycle engines for gasoline, natural gas, or LPG



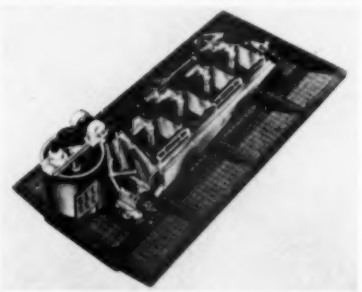
fuel. The new engines have 292 and 331-cu. in. displacements and are rated 105 and 120 hp at 2500 rpm. A twin-six of 240 hp is available. **Circle No. 3**

Shuttle Conveyor

New shuttle conveyor, for use with continuous miners, bridges final gap in mechanized flow of material from mine face to surface. Developed by *Hewitt-Robins* for coal mines, conveyor is adaptable to all kinds of mine and quarry use. Minimum 24-in. belt width handles up to 250 tph. Extendable to 600 or 700 ft, conveyor backward and forward travel to follow mining progress is push-button controlled from fixed discharge point. **Circle No. 4**

Packaged Coal Flotation

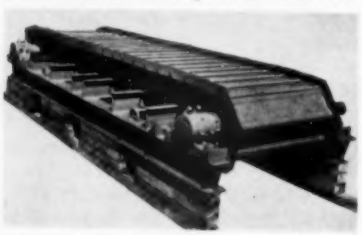
Denver Equipment Co. is building packaged coal flotation plants, to handle —⅛x0-in. fines, in capacities



from 2.5 to 20 tph and larger. A 20-tph unit is stated to cost approximately $23,000. **Circle No. 5**

Apron Feeder

A 9-in. pitch apron feed built by Universal Engineering Div. of *Pettibone Mulliken Corp.* has been de-



signed for extra heavy duty. Half-tooth manganese steel sprockets double tooth life. **Circle No. 6**

High Lift Shoveloader

Developed by *Baker-Lull Corp.*, Minneapolis, a high lift model of the Shoveloader has a lifting height of 16 ft, dumping height to 14½ ft, and a 6000 lb load capacity. A coal and snow bucket and a crane hook increase its versatility. **Circle No. 7**

Safety Valve

Vent-A-Drum safety valve designed by *Central Safety Equipment Co.* is approved by Factory Mutual Laboratories for use on 50-gal drums containing all flammable liquids with the exception of carbon disulphide and diethyl ether. **Circle No. 8**

Diesels Underground

The ¾-yd *Marion* shovel illustrated is handling up to 140 tph in an underground limestone mine in Tennessee. Powered by a *General Motors* 2-cycle engine, the shovel

works 8 to 10 hr per day, but it is stated tests show no hazard to employees due both to nontoxic characteristic of diesel exhaust and adequate mine ventilation. **Circle No. 9**

Particle Analyzer

Precision analysis of particle size distribution is provided by the Micromerograph produced by *Sharples Corp.* Research Laboratories. Particles dispersed in air settle by gravity on a servo-electronic balance which records weight against time, yielding a size distribution curve. **Circle No. 10**

Scoot-Crete

Features for safety in underground bulk materials handling have been built into the N-52 Scoot-Crete announced by *Getman Bros.* The 3000-

lb capacity unit turns in its own 90-in. length, is 43 in. wide and operator's head is about 68 in. from floor level. **Circle No. 11**

Electronic Totalizer

Industrial Electronic Engineers has developed an electronic conversion unit that records net weight readings directly from any dial scale and enters the information into business machines or IBM units. Typical uses of ETS-7 are in controlling batching preparation, and preparing freight invoices. **Circle No. 12**

A. Leschen & Sons Rope Co.

H. K. Porter Co., Pittsburgh, has acquired a controlling interest in *A. Leschen & Sons Rope Co.* of St. Louis. **Circle No. 13**

Free Literature

(21) COMBUSTION GAS TURBINES: Four types of combustion gas turbines for mechanical drives, manufactured by *Westinghouse Electric Corp.*, are described in a 24-page illustrated booklet. The 1800, 5000, 5300, and 7000-hp turbines are presented with load diagrams, drawings, performance curves and colored cut-away illustrations. Twelve factors to be considered in selecting a gas turbine power plant for mechanical drive are listed, together with some of the features leading to lower cost of installation, maintenance and operation.

(22) CORE BARREL: *Sprague & Henwood Inc.* has issued a new bulletin on series "M" core barrel, which, when used with the series "M" coring bit, is stated to help diamond drillers secure higher percentages of good core from fractured, porous, or soft formation. The barrel has been adopted as standard by the Diamond Core Drill Manufacturers Assn.

(23) CRUSHERS: A catalog published by *Smith Engineering Works* covers 24x16, 30x18, and 40x22-in. Telesmith roll crushers for reducing intermediate or fine aggregate at low reduction ratios.

(24) CARBIDE TOOLS: A special condensed price list and catalog, the "Brief-A-Log," includes details on all new prices and specifications of standard cemented carbide tools and blanks produced by Carboloy Dept. of *General Electric Co.*

(25) AUTOMATIC DRILL: An automatic drilling machine featuring an integral air-leg feed and automatic air-water backhead has been announced by *Thor Power Tool Co.* A bulletin describes the new Thor one-man operated machine which combines a 45-lb sinker and a 2¼-in. feed leg in a machine weighing only 80 lb. Among other features are the 6-position throttle control, a single air hose for drill and leg, and an aluminum cylinder and piston.

(26) FEEDERS: *Hardinge Co.* has just published a 12-page catalog on regulating type feeders, giving design details, capacities, dimensions, and application of Constant-Weight, and other types of feeders.

(27) ALUMINUM WIRING: "Electrical Wiring from Alcoa Aluminum" is the latest film in *Aluminum Co. of America's* "How-to-do-it"

series of motion pictures for users of aluminum. Information is available on content of film and how to obtain a showing.

(28) MINE EQUIPMENT: Under the slogan, "Safe-Labor Saving and Self Liquidating," *American Mine Door Co.* has issued a booklet on mine doors, switch throwers, cable splices, car transfers, and other mine haulage equipment.

(29) CYCLONE THICKENERS: *Heyl & Patterson Inc.* has introduced the Jet-Injection cyclone thickener in a new 4-page bulletin outlining application to classifying, thickening, desliming, and water control problems.

(30) TRACTORS: The four diesel-powered *Allis-Chalmers* crawler tractors are presented in "Inside and Out" in a unique way; the new catalog shows details of construction of each model with full cutaway pictures. An illustrated spread tells the job application story for each model.

(31) WIRE ROPE STORY: In 56 continuous scenes like a film, a novel booklet from *Macwhyte Co.* presents a picture story of wire rope manufacturing from wire rods to final assembly and testing.

(32) MOLYKOTE LUBRICANT: An 8-page catalog describes in technical detail various industrial grades and compositions of Molykote lubricants produced by the *Alpha Corp.* Basic ingredient of these lubricants is molybdenum disulphide, whose unique molecular properties resist high bearing pressures and provide maximum surface adherence.

(33) PACKAGE CONVEYOR: The portable Trow-Veyor, package handling conveyor for boosting, loading, and stacking, is described in a 4-page bulletin from *Trowbridge Conveyor Co.*

(34) BERYLLIUM PRODUCTS: Pure metal, oxide, and alloy beryllium products are described in a 20-page product directory issued by *The Beryllium Corp.* The directory covers in concise form commercial beryllium products used for corrosion resisting, nonsparking, and nonmagnetic properties.

(35) WIRE ROPE FITTINGS: *Sauerman Bros. Inc.* has available a brochure for users of wire rope fittings containing drawings, tables and ordering information on open and double wedge sockets, pins, and continuous cable clamps.

(36) BELT DATA: A new "simple-to-understand" 48-page technical manual on transmission, conveyor,

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for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

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and elevator belting, offered by *Boston Woven Hose* and *Rubber Co.*, is stated to contain "Every phase of belting of interest to engineers recorded in tables and charts."

(37) VIBRATING SCREENS: A bulletin from *Deister Machine Co.* gives complete information on Deister heavy duty type ETP and ETU high speed vibrating screens. Operational features are described, performance characteristics listed, and exclusive features illustrated.

(38) STEEL FOR MINING: "For More Profitable Mining" is title of folder from *Armco Drainage and*

Metal Products Inc., aimed to "spark an idea on how to cut costs, improve safety or save time."

(39) DRILL BITS: Rock drill bits for all purposes are listed in a 24-page booklet from *Brunner & Lay.*

(40) FILTERS: Continuous drum vacuum filters that are fully automatic and disc filters for filtering more than one character of concentrate or material where separate filtrates are desired are described in Bulletin No. 4710 published by *Morse Bros. Machinery Co.*

(41) DEMINERALIZERS: *Barnstead Still* and *Sterillizer Co.* announces a publication on mixed-bed water demineralizers for producing high purity water by ion exchange.

(42) DIESEL DESIGN: A new 48-page booklet from *Murphy Diesel Co.* gives details of engineering design features to look for in diesel engines, and presents ratings and specifications of Murphy diesels.

(43) FIRE PUMPS: *Ingersoll-Rand Co.* has available a descriptive bulletin on its line of horizontal single-stage and vertical, multi-stage fire pumps.

(44) ELECTRONIC WEIGHING: Typical applications of *Baldwin-Lima-Hamilton Corp.* crane scales and instruments for weighing loads electronically are shown in an illustrated brochure which shows how these scales, utilizing a bonded resistance wire strain gage, are installed and used.

(45) SOUND SIGNALS: A combination manual, data book, and catalog issued by *Benjamin Electric Mfg. Co.* is termed the most complete reference ever published on industrial sound signals for safety, control, and warning.

(46) IMMERSION HEATERS: A new electric immersion heater catalog featuring application data for calculating power requirements for heating processing tanks has been prepared by *Cleveland Process Co.*

(47) LOW-VOLTAGE CONTROL: A new 16-page picture story on Cabinetrol low-voltage control systems is available from *General-Electric Co.*

(48) CABLE FAULT FINDER: *Joy Mfg. Co.* is now marketing a light weight cable fault finder for locating open circuits and shorts. Further details are now available on the 23-lb unit said to be ruggedly constructed and simple to operate.

(49) HARD FACING: *Alloy Rods Co.* has a new catalog on Wear-Arc hard-facing electrodes and Wear-Flame hard-facing rods. Data from "how-to-do-it" standpoint and application guide give correct rod or electrode for about 75 common types of hard-facing problems.

(50) FLAW LOCATION: Dy-Chec nondestructive method of locating cracks and flaws in metals through surface-active chemistry is covered in a booklet from *Turco Products.*

(51) PUMP MOTORS: *The Louis Allis Co.* has a bulletin on hollow and solid shaft vertical pump motors.

(52) INSTRUMENTATION: How consistency and acid concentration of slurries are controlled by instrumentation devised by *The Foxboro Co.*, is described in a new data sheet. Originated for titanium pigment production, the system is said to have extensive possibilities for other processes.

(53) LIFETIME ROOFS: "One Roof in Your Lifetime" is booklet on *Roliton* aluminum roofs. Patented clips, battens, and pans for eliminating contraction and expansion problems are featured.

(54) CHAINS: *Wilmot Engineering Co.* publishes a 248-page catalog said to be the standard reference on rivetless chain for all applications. Chain sizes and attachments are listed as well as parts for conveyors and elevators.

(55) SAFETY INFORMATION: "Dangers Under Pressure" is a new safety booklet distributed by *Hose*

Accessories Co. to aid hose users in securing long, trouble-free, service and in avoiding serious accidents.

(56) TORQUE LIMITING CLUTCHES: An illustrated engineering data sheet describes the new line of *Morse Chain Co.'s* Torque-Limiting slip-type friction clutches for overload protection of machine drives.

(57) FEEDER: A gravity type liquid feeding device known as the Liquifeeder has been marketed by the *Hankison Corp.* Feed rate may be varied from half a pint to over 500 gal per day by regulation of the valve that meters air to the tank.

(58) CIRCUIT BREAKERS: New booklet from *Westinghouse Electric Co.* shows how circuit breakers save money and discusses application of AB-1 circuit breakers to reduce down time and maintenance.

(59) MULTIPURPOSE HOSE: "The Basic Five" hoses are discussed and a multi-purpose selection chart is provided in a *Thermoid Co.* booklet.

(60) WELDING RODS: *Alloy Rods Co.* has just released a 20-page catalog on its complete line of Arcaloy Stainless Steel Alloy electrodes.

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These and many other advancements, still exclusive with P&H, mean steadier, faster digging. That, in the final analysis, means lower tonnage costs. If that's what you're looking for . . . P&H is your answer.

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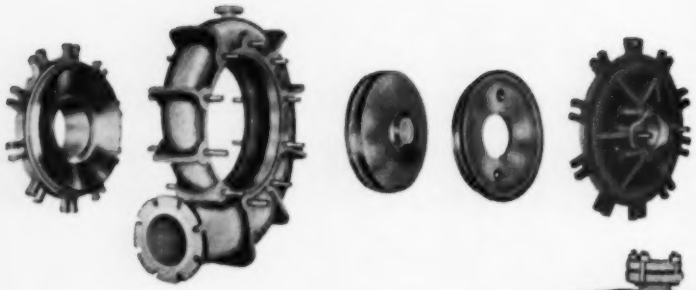
MILWAUKEE 46, WISCONSIN

the P&H *Line*



Nickel-Chromium White Iron is utilized to provide abrasion-resisting components for all GIW slurry pumps. Capacities of these units range from 50 to 8000 gallons per minute against heads up to 150 feet.

How slurry pumps defeat abrasion

... Give maximum life per dollar invested

The outstanding performance of pumps engineered and manufactured by the GEORGIA IRON WORKS CO., Augusta, Georgia, demonstrates the superior wear resistance of their GASITE® – a nickel-chromium white iron with high hardness and exceptional resistance to abrasion...

GIW slurry pumps are especially designed to utilize this long wearing nickel alloyed white iron as a means of increasing unit efficiency and cutting maintenance costs.

Users of these pumps maintain steady output and thus avoid the production losses and other expenses that follow shutdowns for replacement or repairs.

In all sorts of applications, nickel alloyed irons and steels prove their superiority day after day. Consult us on the advantages they can provide in your products or equipment. Whatever your industry, when you have a metal problem send us the details for our suggestions.

At the present time, nickel is available for end uses in defense and defense-supporting industries. The remainder of the supply is available for some civilian applications and governmental stockpiling.

EMBLEM OF INCO SERVICE

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

United States Steel Co. expects to import some 7.18 million tons of iron ore and manganese ore through the port of Baltimore by 1960. The steel company is planning a fleet of carriers with over-all length of 735 to 800 ft. Carriers will have a capacity of about 42,000 long tons.

Reserve Mining Co's taconite processing plant under construction near Beaver Bay, Minn., has been named the E. W. Davis Works, in honor of E. W. Davis, long director of the Mines Experiment Station of the University of Minnesota.

A new sulphur recovery unit of Gulf Oil Corp. at Waddell, Texas, produced 12.75 million lb. of sulphur. Chief significance of the installation is its conversion of the final remainder of what was once an oil field waste into a valuable product.

Defense Materials Procurement Agency signed five more contracts for Mexican manganese production, thus completing its goal of 550,000 tons of Mexican manganese under contract. New contracts cover production of 133,500 tons. All manganese produced under the pacts will be delivered to an El Paso depot.

It may be some time before manganese is shipped from recently disclosed deposits in French Equatorial Africa. U. S. Steel has a 49 pct interest in the French firm Comilog. French sources claim the deposit contains an estimated 50 million tons of ore of a grade said to compare favorably with Russian ores. The mine is about 250 miles inland from Point Noire.

The 6500 ton flotation mill at Noranda's Subsidiary, Gaspe Copper Mines, is scheduled to start up by October 1954. Some 1700 men are currently employed in establishing an industrial installation in the Gaspe wilderness.

The Export-Import bank announced a loan of $22.4 million to Rhodesia Congo Border Power Corp. Ltd., of Northern Rhodesia. Expanded power supplies will enable Rhokana, N'Changa, Mufulira and Roan Antelope Mines to expand copper and cobalt production. In return for the increased power, the power firm will be able to pay off the loan with metal from the advanced output.

Canadian Javelin Foundries and Machine Works Ltd., of Montreal, has been granted a concession of 1,472,000 acres in southwest Labrador in the 3,056,000 acre mineral concession held in that area by Newfoundland and Labrador Corp.

According to reports, the United Mine Workers has been advised by the Bureau of Internal Revenue that the union's welfare and retirement fund does not rate income tax exemption.

DMPA will pay up to $517,000 for construction of a pilot plant by E. S. Nossen Laboratories. The company will use the plant to test a nitric acid process for treatment of manganese ores from Aroostook County, Maine.

Colitz Coal Co. replaces

To uncover vertical anthracite veins near New Philadelphia, Pennsylvania, Colitz Coal Co., Inc., Pottsville, is stripping 350 ft. of dirt and rock under really tough conditions. Overburden, largely conglomerate rock, weighs from 2670 to 3400 lbs. per cubic yard. Haul of 1000′ to spoil pile is all uphill, with grades averaging 20%. Haul roads are rough and contain a series of 90° switchbacks. "This is considered one of the toughest jobs in the region," says Co-Owner John Colitz. "It's *all* grades."

To lick such grueling conditions, Colitz Coal Co. purchased 3 big 50-ton "A" Tournarockers. After a year's operation with these giant Rear-Dumps they report output like this:

Move 40 to 51-ton loads up 20% grades

Loaded by a 6-yd. shovel, Tournarockers get an average yield of 30 cu. yards per load, according to company records. On a weight basis, that's 40 to 51 tons per load, depending on the material. In good weather and bad, the year around, the Colitz rigs keep hauling these big loads up the 20% incline — 7½ hours per shift, 3 shifts per day, 6 days per week. Says Mr. Colitz, "We make as high as 50 trips per shift on this steep cycle. If we didn't have these 3 Tournarockers, we'd have to use 10 other haulers."

Tournarocker's simplicity of design and unusual maneuverability give Colitz Brothers other valuable savings, too. Maintenance crews report these rigs can be completely greased in 2 hours (as compared with an entire 8-hour shift required to grease competitive trucks). Also, Tournarockers are able to get around sharp right-angle cutbacks without backing for a second try — something other rigs could never do. With 90° power steer, fingertip electric controls, and 4-wheel, multi-disc air brakes, Tournarockers

HIGH-SPEED, RUBBER-TIRED HAULING • EXCAVATING • LIFTING EQUIPMENT

Tournarocker dumps load clean over bank, needs no dozer clean-up. Front-wheel drive, multi-disc 4-wheel air brakes (with 9408 sq. in. total braking surface) assure perfect safety.

Giant 50-ton Tournarocker is loaded with 40 to 50 tons of blasted conglomerate rock by 6-yd. shovel. 13' x 17' bowl target speeds shovel swings, reduces spillage.

10 trucks with 3 Tournarockers

get under the shovel faster . . . position for dumping faster . . . and return to shovel faster.

"Cut operating costs 40%"

With performance like this, Colitz has assigned most of his hauling work to the Tournarockers . . . uses the four 12 and 15-ton trucks remaining from his earlier haul fleet for emergencies only. Company records show that 95% to 98% of total overburden moved in the past year was hauled by the 3 Tournarockers. *"Costs are low, too,"* says Mr. Colitz. *"Since using Tournarockers, we've cut operating costs by 40%!"*

Whenever *you* have rock, ore, or other shovel-loaded material to haul, it will pay you to compare your present output with that reported by Tournarocker owners. Ask your LeTourneau Distributor for complete facts on Tournarockers. There's a size to fit your needs — 9 to 50 tons.

Tournarocker—Trademark Reg. U. S. Pat. Off. AR-301-CM

Loaded with 30 yds. of overburden, rig starts 1000' haul up continuous 20% grade. Return is made down same grade. With power steer through geared kingpin, these 50-ton units can turn around in a radius of 15'8" — less than half their 36' overall length.

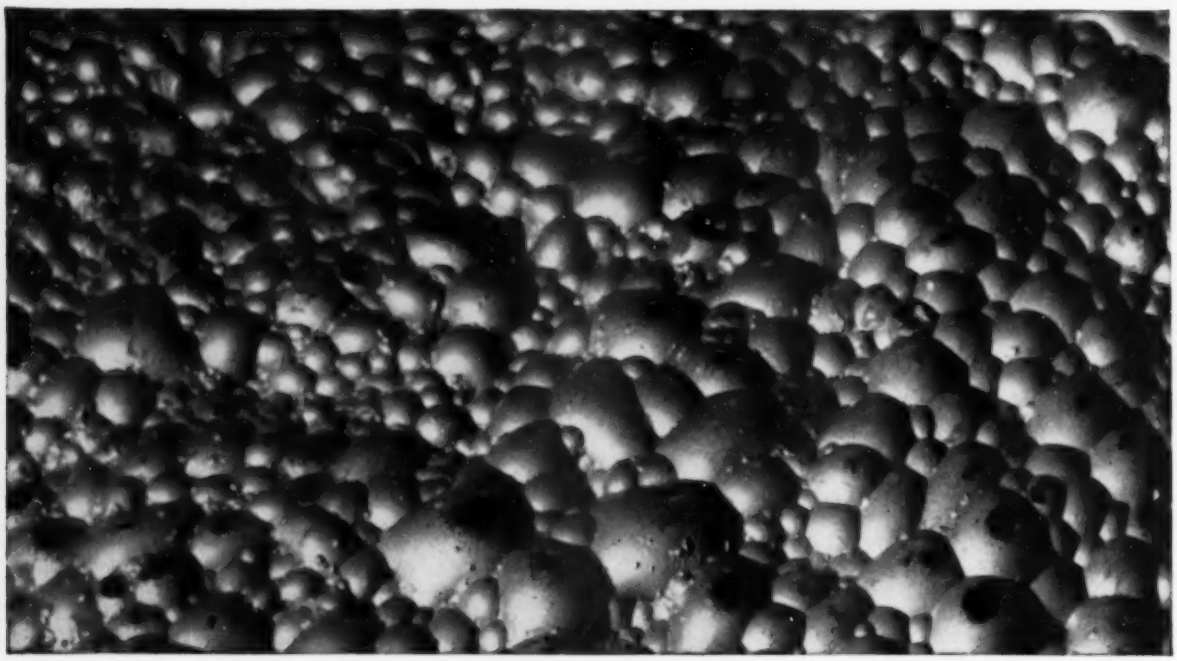
LeTourneau-Westinghouse Company

PEORIA, ILLINOIS

DOW

DOWFROTH 250, AN IMPROVED FROTHER AT LOWER COST

DOW'S quality frothing agent raises concentrate grade—increases recovery—with reduced frother consumption!



In many mills today, Dowfroth* 250 is producing improved metallurgy with as little as one-fourth the consumption of previous frothers used. This translates into increased profits and substantial savings in your mill operation.

Dowfroth 250 is easy to use, too . . . it requires minimum conditioning time for stage addition; its water solubility permits accurate regulation as a water solution, if desired; and it demonstrates little or no collecting power, allowing you freedom to regulate frother and collector independently.

As a pioneer producer of Xanthates, Dow has built up extensive facilities for the manufacture of flotation agents, assuring you adequate supplies of Dow Xanthates and Dowfroth 250 of dependable high quality at all times.

Prove, in your own mill, the economy and efficiency of Dowfroth 250. For a test sample of this dependable frother, write to THE DOW CHEMICAL COMPANY, Midland, Michigan, *Dept. OC 3-39.* *Trademark

you can depend on DOW CHEMICALS DOW

Abandoned Mines May Serve for Oil Storage

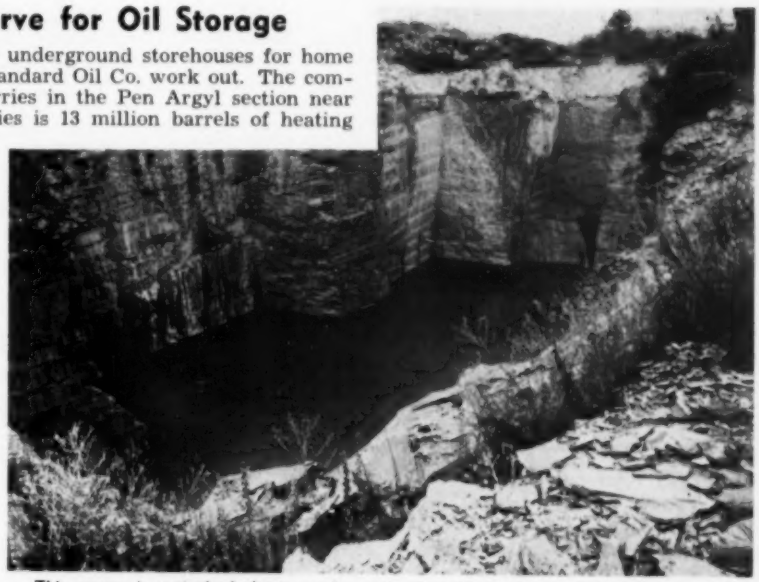
Abandoned slate pits may someday be underground storehouses for home heating oil, if plans projected by Esso Standard Oil Co. work out. The company has taken options on 11 slate quarries in the Pen Argyl section near Bethlehem. Total capacity of the quarries is 13 million barrels of heating oil, or enough to heat more than 325,000 average homes. William Naden, Esso Standard vice president in charge of manufacturing, said the project has tremendous possibilities for the petroleum industry in meeting the growing seasonal nature of its operations.

Pits range from 100 to 300 ft deep, 200 to 500 ft long, and 140 to 270 ft wide. Only roofing and minor engineering would be necessary to convert the pits to large storage areas. Mr. Naden emphasized, however, that as highly significant the success of the development might be, it would not eliminate the need for increasing other storage areas along the East Coast.

It was pointed out that suitable mines and quarries require less than 10 pct of the steel needed in above-ground storage. They are almost completely immune from storm or bomb damage.

The company is considering initial operation of only one pit with a capacity of 3 million bbl. The mine is 270 ft deep, 350 ft wide, and 250 ft long. Pipe line capacity limit will hold storage to about 1½ million bbl. It will take about a year and $1 million to complete facilities. Except for a few feet of clay or gravel overburden, walls of the quarries are essentially vertical and composed of solid slate. All pits are partially filled with water.

Water will be removed from the bottom of the pit as oil is pumped in at the surface. To insure that the water pressure on the walls of the pit is always greater than oil pressure, oil level will be held below that of the surrounding water table. Biggest problem is the type of roof to be used.



This quarry is typical of the type chosen by Esso Standard for consideration as oil storage reservoirs. It has been allowed to fill with water from rains and seepage. The pit is 270 ft deep, 350 ft wide, 250 ft long. It has a potential capacity of 3 million bbl. This pit will be used for initial experiments.

USSR Reported Selling Manganese Ore in West

It has been reported in London that small quantities of manganese ore have been sold by Russia to Belgium, Germany, and Italy. Another report has it that Russia has offered France about 40,000 tons at a price slightly below that of the world market.

The Russian offer is believed to be under the London market price which is quoted at about $1.00 to $1.10 per long ton unit of high grade ore.

It has also been reported that Russia offered 3000 tons of platinum a short time ago.

Public Land Withdrawn For Uranium Ore Search

Additional lands in Utah have been segregated from the public domain for use in the Atomic Energy Commission's uranium exploration program, it was announced by the manager of the Grand Junction Operations Office.

Lands affected are in the Calf Mesa area in Emery County and the Deer Flats area in San Juan County, Utah. The action is a continuation of the Commission's effort to develop sufficient uranium ores to keep production on the Colorado Plateau at a maximum.

Areas to be withdrawn have been noted in the Tract Books maintained in the Utah Land and Survey Office, Salt Lake City. Recording of these lands constitutes a temporary segregation of the lands from entry until final determination and disposition of the lands has been made.

Johns-Manville Buys Asbestos Ore Deposit

Johns-Manville Corp. purchased a newly discovered asbestos ore deposit in northern Ontario, according to A. R. Fisher, corporation president.

Purchase of the property, in Reeves Township, is in the same general area as Johns-Manville's Munro mine and mill near Matheson, Ont. The purchase was made in keeping with a long range plan to maintain adequate asbestos reserves, although no plans have been made for production from the property. According to Mr. Fisher, Canadian production combined with that of other nations is ample to meet world needs at this time.

"Production of and demand for asbestos fibre are now in balance and our forecasts indicate that this situation will continue for some time."

Construction of the Munro mine and mill was completed in 1950. Since then Johns-Manville has acquired additional ore bodies in its vicinity. The company is also directing development of asbestos properties in Southern Rhodesia. A new mill is under construction with operations expected to begin in 1954.

Third Uranium Plant Opens in S. Africa

South Africa's third uranium recovery plant at Blyvooruitzicht mine in the Western Rand has officially begun operation. The plant was ceremoniously opened by W. H. A. Lawrence, general manager of the Central Mining & Investment Corp. in South Africa.

The plant is the latest in a $112 million development project. Mr. Lawrence, in his address, said that modern research encouraged the hope that "the day is not far distant" when need for uranium "for warlike purposes will be overshadowed by its demand for peaceful uses."

Contract System Spells Good Administration for U. S. Vanadium

A United States Vanadium geologist inspects cores recovered from exploratory diamond drilling operations. The company does all engineering work.

SIXTY mines, spread over an area 100 miles long and 20 miles wide producing anywhere from 10 to 350 tons of uranium ore per month, pose a tremendous administration problem to the parent company. Add a rather sketchy road network and almost nonexistent communication services typical of the Uravan area on the Colorado Plateau and the problem grows more difficult. United States Vanadium Co., a division of Union Carbide & Carbon Co. is in just such a situation—except it has gone a long way toward solving the problem.

Uravan, about 90 miles from Grand Junction, Colo., is rapidly becoming world famous because of its principal industry—mining and concentration of uranium and vanadium oxides from carnotite ore. When Uravan operations were restarted in 1948 after a three year period of inactivity, the contract system appeared to offer the answer to mine operation. The system used by U. S. Vanadium bears a strong resemblance to the one used at Cripple Creek, Colo., many years ago.

Men who knew the mines were available. They had worked as miners and foremen prior to shutdown of operations in 1945. These men had the knowledge needed to mine the carnotite ore, the willingness to work, and management ability. The last attribute is possibly the most important. Under the contract system each contractor supervises, directs, and controls his employees. Equipment is rented to the contractor by the company. He is charged a nominal rate based on value of equipment and must provide general maintenance. Major repairs and overhauls, when needed because of fair wear and tear, are provided for by the company.

Several contractors realized that over a period of years the money they were paying in rental would buy the machinery. They turned back the rented units and purchased their own. The company, in turn, outfitted other contractors with the returned machinery.

Everett M. Paris, of U. S. Vanadium, at a meeting of the Colorado Mining Association at Denver, had this to say on the contract system:

"When the supply of local miners and shift foremen with the necessary qualifications to make a successful contractor was exhausted, we had to rely upon experienced hard rock miners and lessees from the San Juan Country and Cripple Creek. These men have turned out to be some of our most successful contractors, and this brings out the point that a good experienced hard-rock miner, who has good managing ability and who is willing to work, will make a successful mining contractor in the carnotite field. . ."

Contracts were first drawn for a six months period; then were usually renewed. Later, contracts were made for a one-year period in the majority of cases. With the exception of one or two, the original contractors are still on the job.

A specified tonnage is delivered by the contractor each month. The contractor makes no commitment as to the number of shifts worked each month, the number of men he employs, or the wages he pays. However, he must conform with the Taft-Hartley Act, Fair Labor Standards Act, and the Walsh-Healey Act. Standard mining practice must be adhered to, and all federal, state, and local health and safety regulations must be obeyed. The contractor must also carry workmen's compensation, and liability insurance.

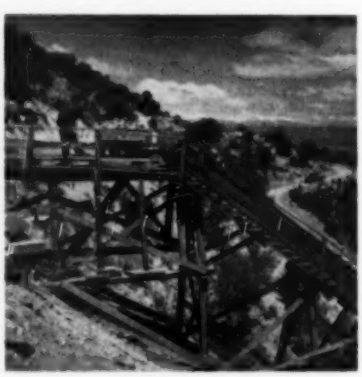
All engineering work is done by the company. This includes planning, road building, ore bin construction, diamond drilling, wagon and churn drilling, and exploration work including diamond drilling underground. The contractor is paid for certain work not directly productive of uranium ore. Cleaning up caved areas in old mines, retimbering old mines, sinking inclines, driving barren drifts, and putting in ore passes or raises are paid for on a shift or per foot basis.

An operating department man or an engineer estimates the number of shifts needed to do a particular job. When the task is completed the contractor is paid at the prevailing wage for the estimated number of shifts. However, per foot basis is used to determine payment for development work, driving raises, inclines, shafts, providing the work is done in barren ground.

The contract is nonassignable and can be terminated in 30 days with written notice by either party, or in event of violation of contract, with five days notice by the company. The contractor is paid about 50 pct of Atomic Energy Commission value for ore delivered to U. S. Vanadium. Probably one of the most significant statements in the contract is that the contractor is at all times in complete charge of his operation.

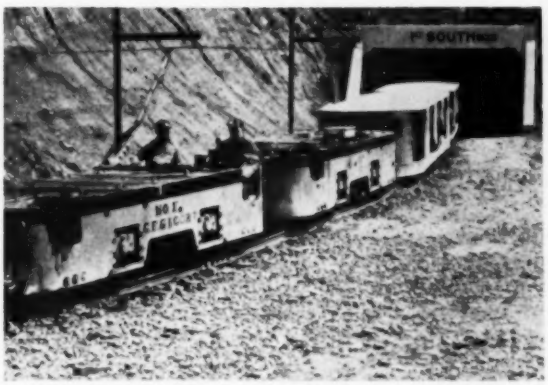
Under this system U. S. Vanadium has had much of the load of management lifted from its shoulders. Industrial problems, usually found in operation of remote interests are almost nil. Several successful individual enterprises owe their existence to the contract system. In addition to the mine contractors there are diamond and wagon drill, churn drill and trucking contractors in operation as a direct result of the contract program. Community leadership has developed and the Plateau is a better place to work and live, according to Everett Paris, of U. S. Vanadium, because of the success of the contract system.

A small compressed air locomotive pushes an ore car out of the mine portal. Contract miners may rent equipment from company or buy their own. Many have chosen to make the necessary investment.



Rugged country dictates that many of the mines have inclined chutes running down the sides of the mesas to ore bins below. A specified tonnage is delivered each month by the contractor.

CF&I'S Allen Mine Production Goes Into High Gear



Men ride in and out of the Allen mine on cars equipped with steel roofs, preventing injury from falling rock while in transit. Safety gets heavy emphasis in the Allen mine, a Colorado Fuel & Iron Corp. operation.

Another safety device is this totally enclosed portable circuit-center in the mine. The circuit-center is dust, gas, and waterproof. The Allen mine is proud of its mechanization.

About 40,000 tons of coal monthly are coming out of Colorado Fuel & Iron Co.'s Allen mine, near Stonewall, Colo., for an all-time production high in the operation. The mine has been one of the most significant factors in CF&I expansion at Pueblo where the firm's fully-integrated steel mill is located.

Coal production started from the West Portal of the Allen mine last year, and from the East Portal early in 1953. A. F. Franz, CF&I president, has great hopes for the Allen mine.

"We expect this mine to become one of the largest coal producers in the Rocky Mountain area in years to come."

Aside from production figures, CF&I is most proud of the degree of mechanization that has gone into the mine. New techniques in mechanization have brought a peak of productive efficiency. "Brains and skill much more than brawn" is required of the miner working in the Allen operation. From the time coal is cut by a 9½-ft cutter chain, making either horizontal or vertical cuts in the seam, machines do the work. Loading machines scoop up the coal and carry it directly to shuttle cars. The cars move 4 tons of coal from excavation point to a loading station within 350 ft of the digging place.

Rubber conveyor belts traveling at 250 to 400 fpm carry coal to underground storage. The main conveyor belt takes over and carries 700 tons of coal per hr to the surface. Push buttons control the cleaning and sizing operations above ground.

Safety

Old fashioned timbering has been eliminated in the Allen mine in favor of roof bolting to hold overlying rock strata together. "Miners' subway" cars are fitted with heavy steel roofs—no worry about rock falls. Electrical safety is provided by a portable circuit-center.

Belts for Everything

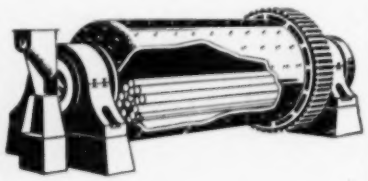
Conveyor belts really get a workout in CF&I's ore preparation plant at Pueblo. Three miles of belt—30 belts 3 ft wide—travel underground, up steep inclines, and through tunnels, to transport raw materials to and from freight cars, crushers, and storage bins and piles. Switches make it possible to reverse the flow, bypass operations, or fill cars.

Iron ore and limestone travel separately over the belt system. Limestone is routed almost directly through the crusher and on to the new loading system. Ore passes through crushers and screens where fine particles are removed for sintering. The balance of the ore is conveyed to blending piles.

For an account of CF&I's new Petit char plant for aging of coal, see this month's *Trends*.

The main conveyor belt brings coal from the mine to the surface. Other conveyor belts carry coal to underground storage areas where it is kept until transferred aboveground on the main belt.

CF&I people say that it takes more brains than brawn to work in the Allen mine because of the extensive use of modern equipment. A miner inspects a coal cutter that can make either horizontal or vertical cuts into the seam.



World's
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is
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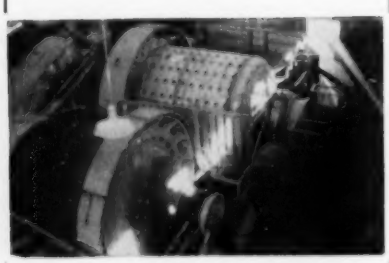

Consolidated Mining & Smelting Co.'s Hardinge 11½' x 12' Rod Mill shown here with a 10' x 48" Hardinge Primary Conical Mill is doing an outstanding job.

Capacity: 8600 tons per day.
Liner Consumption: .0168 lbs. per ton.
Rod Consumption: 0.354 lbs. per ton.
Horsepower: 930.

Bulletin AH-441-2

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Mines Bureau Advances in Manganese Research

Recent reports from the Bureau of Mines on recovery of manganese from low grade western ores indicates that progress is being made. Three processes developed during two years intensive research at Salt Lake City and Tucson, Ariz., laboratories have been partially proved in 18 months of pilot plant operation at Boulder City, Nev. However, much remains to be done before commercial ventures can be undertaken.

Congress authorized flotation and hydrometallurgical pilot plants at Boulder City. Work done at Salt Lake City and Tucson was on ores from the Artillery Peak, Ariz., district.

In the first process, ore containing about 11 pct manganese was finely ground and then separated by flotation to recover a concentrate assaying 35 pct manganese. Tests indicate that the nodulized or sintered concentrate can be smelted in an electric furnace to produce ferromanganese, although pilot plant operation shows that silicon content reduction will be difficult.

In the second process the ore was concentrated by flotation to yield a concentrate and middling product with an over-all recovery of 85 pct manganese. The middling product was then leached by the Bureau-developed dithionate process in which manganese is extracted with sulphur dioxide and recovered by precipitation with lime. Practically all the manganese is recovered as a +60 pct precipitate for blending with the flotation concentrate to obtain a product suitable for smelting to ferromanganese.

The third method is a modification of the first two. A 60 pct manganese precipitate was recovered by dithionate leaching of a portion of the crude ore. This precipitate is blended with flotation concentrates produced by the first process to yield a ferrograde manganese product.

The last two approaches seem to hold the most promise according to Bureau officials. Ore concentration studies are more advanced than leaching or smelting, for a practical flotation process has been proved.

Aerial view of Southwest Experiment Station, Bureau of Mines, Boulder City, Nev., where pilot plant research on recovery of manganese has produced encouraging results. Studies are now in progress to determine if it is possible to reduce production costs.

Chief Consolidated Signs DMPA Contract

Chief Consolidated Mining Co. property in the Tintic mining district, Utah, is to be reconditioned for large scale production of lead and zinc, according to a contract between the company and Defense Materials Procurement Agency.

An estimated 487,000 tons of ore will be developed by the Salt Lake City firm. Estimated cost of the project is $1,416,865, with DMPA advancing up to $283,373. The loan is to be repaid with interest from returns of production.

The development, part of an extension of an exploration contract between the company and DMPA, will extend over three years.

Climax Promises Aid To Stricken Leadville

Climax Molybdenum Co. intends to take all reasonable steps to ease the blow to Leadville resulting from the closing of Resurrection Mining Co., according to Weston Thomas, Climax treasurer.

The closing of Resurrection operations and essential stoppage of milling operations has dealt Leadville economy a serious blow. Leading citizens are attempting to work out a program to keep a mill in operation in the district.

In speaking to the Leadville Chamber of Commerce Mr. Thomas noted, "By January 1, 1954 Climax will rate as the second largest underground metal mining company in the world. It is presently producing 23,000 tons a day and expects to hike this tonnage to 28,000 within a few months."

Mr. Thomas said that Climax will continue at capacity during 1956 with substantial operations continuing through 1962.

Idarado Mine Swept By Disastrous Fire

Idarado Mining Co., Colorado, is battling to get back into production after a disastrous fire caused from half to three-quarters of a million dollars worth of damage to the Treasury Tunnel.

Machine shops, an assay office, a warehouse, timber shed, change room, and a compressor house were completely gutted. Estimate of damage was made by Mine Superintendent John Wise. Operations will resume when buildings are replaced.

Group Exploring Ancient Mich. Mines

A group from Michigan College of Mining and Technology is searching into the prehistoric past of Michigan copper mining. Last fall Joseph C. Gannon, Marquette business man, presented Michigan Tech. with a grant for exploration of the Isle Royale area in Lake Superior.

Miners opening copper mines during the 1840's told of finding hundreds of prehistoric mine pits. Some of the pits contained stone tools and cribbing. Based on the discoveries of a copper knife found in the remains of a mastadon in Missouri, belief has arisen that copper mining in Michigan may date back to the stone age. According to estimates made by historians, some 2 million lb of copper may have been extracted from Isle Royale mines.

Roy W. Drier, professor of metallurgical engineering at Michigan Tech., heads the expedition.

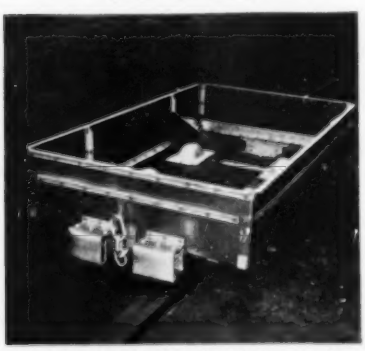
N. J. Zinc To Sink Shaft in Tennessee

New Jersey Zinc Co. announced plans to sink a shaft later this year on its property one mile south of Jefferson City in the mineralized area of eastern Tennessee.

The property was acquired in 1947. Drilling started the following year and culminated in the decision to work the deposits. The first shaft will be sunk about 1200 ft. A mill with a 1000 ton per day capacity is also contemplated.

The orebody is lead-free zinc sulphide ore, typical of other zinc occurrences in eastern Tennessee. Johnson Crawford, Tennessee superintendent for New Jersey Zinc, will conduct operations. The area is served by the Southern Railway.

New Jersey Zinc operates mines in New Jersey, Pennsylvania, Virginia, Colorado, and New Mexico.



Reynolds Metals Co. has built an aluminum coal mine car with a body weight of only 1614 lb. In comparison, a steel car would have a body weight of 4417 lb. The car is to be used by Pocahontas Fuel Co. at its Ittmann mine near Mullins, W. Va.

YUBA PLACER DREDGE DIGS, TREATS, STACKS 18,000 TONS GRAVEL DAILY...

This placer dredge with 18 cu. ft. buckets digs to 125' below water, averages better than 22 hours running time daily. Intricate treatment equipment on board limits digging to only 18,000 tons of gravel per day. For sand and gravel digging only, an 18 cu. ft. YUBA dredge can produce as much as 40,000 tons daily.

5¢ Per Ton

YUBA gold dredges of this type can be converted readily to produce and size gravel at total operating costs substantially under 5¢ a ton. One big advantage—they float in their own ponds and excavate gravel without lowering surrounding water levels.

Long Operating Life

With YUBA dredges you get both low production costs and long operating life—many YUBA dredges are operating efficiently after 25 years or more of rough service.

Consult YUBA NOW. We will design and build a new dredge to fit your ground; or help you find a used dredge, and move, redesign and rebuild it. Wire, write or call us—no obligation, of course.

Profusely illustrated, 40-page brochure, "YUBA Dredges," yours for the asking.

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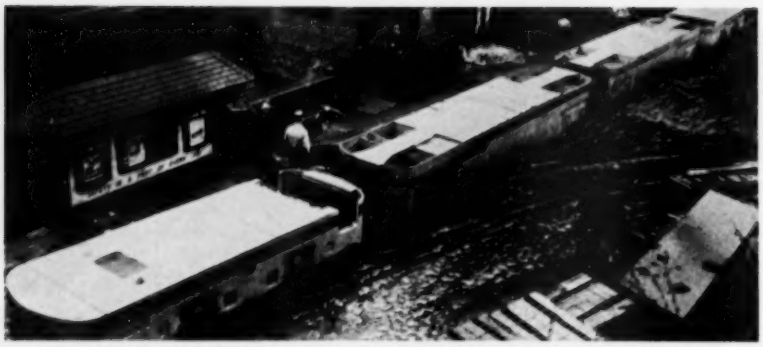

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CF&I

1907

Yugoslav Mine Experts Visit U. S. Operations

Yugoslavia sent ten nonferrous mining men to the U. S. to study open pit and underground mining operations in an attempt to boost its production of strategic materials.

Mine managers, engineers, and research institute officials made a six weeks tour of American operations under the auspices of the Mutual Security Agency's productivity and technical assistance program.

Lack of men with knowledge of modern mining methods has been one of the chief obstacles in Yugoslavia's efforts to develop its potentially large nonferrous mine yield.

Among the plants visited were The Dorr Co., New Jersey Zinc Co., and Bethlehem-Cornwall Co. Several other operations were on the itinerary.

Europe to Slash U. S. Coal Imports

Western Europe will cut its imports of American coal to half the total of 1952, according to estimates made by the coal committee of the Organization for European Economic Cooperation.

In 1952 Western Europe imported some 20.2 million tons of coal from the U. S. Increased coal production in OEEC countries to an estimated 487.2 million tons in 1953 and a slackening in industrial activity mean that imports can be reduced, according to the coal committee's report.

Some American coal will be needed, however, because of the shortage of good coking coal. European coal producers are asked to stress production of this type of coal.

Only Nickel Remains Under Complete Control

Only nickel remained under complete control, including allocation, following the action by National Production Authority dropping molybdenum, columbium-tantalum, and cobalt from the allocation control list.

Inventory and reporting controls were also removed from the liberated metals. Provisions of Schedule 5 restricting the use of columbium-tantalum are retained in order M-80, which removed allocation control from the metal. Columbium or columbium-tantalum steels shall be produced, sold, delivered or purchased only to fill orders placed by the Defense Department, Atomic Energy Commission, or manufacturers of Class A or B products required by the Defense Department, AEC, or certain special uses.

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THE QUALITY LEADER IN COMPRESSORS, PUMPS AND ROCK DRILLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

WITH the announcement by Brunswick Mining & Smelting Co. of a plan for major operations and the awakened interest of other companies in the region, the Bathhurst area in Canada is beginning to show signs of being one of the busiest mining centers in the country. Brunswick is thinking of production in terms of 5000 tons per day. Recently, the company completed drilling its main orebody down to 1000 ft. Two machines are still at work in other exploratory projects. Caving ground has produced some trouble, and drills haven't disclosed any certain information on the value of a new anomaly 12,000 ft to the east of the main body. However, lead and zinc mineralization has been reported.

Ore on the last and deepest hole in the main orebody came in at 1268 ft, about 1000 ft vertical depth, and showed 117 ft averaging 9 pct zinc and 2.84 pct lead. Major development problems have yet to be considered. Townsites, roads, and a shipping port are among the many things that will have to be planned. Financing is another matter. American and Canadian interests have made offers, it is reported. In New York, Brunswick President M. J. Boylen is quoted as saying, "Of one thing you can be sure, there will be no problem in raising the money."

Town and plant sites have already been cleared, and it may be that the next step will be sinking a shaft. While the mining method has not been resolved, it is almost certain that the operation will be opened underground as soon as feasible.

In the meantime, other companies have started to intensify activities. Geophysical work and diamond drilling in the area have been increased with more than a dozen drills operating and even a greater number of geophysical teams in the field. Almost all claims are under investigation. The pace has accelerated because of the Anacon-Leadridge discovery, which moved many operators off the seat of their pants and into a state of action.

Maritimes Mining Corp. was reported sinking its fifth hole in a location north of Brunswick. Fab Metal Mines is operating north of Maritimes with two drills working. South of Brunswick, Bathhurst is completing two drill holes. New Highridge Mining Co. is drilling east of Brunswick.

Among the many other companies busily engaged in drilling and exploration are New Jersey Zinc Co., Noranda Mining Corp., Cyprus Corp., Quebec Mining & Smelting Co., and a St. Joseph Lead Co. subsidiary.

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MINING will continue to be one of the major economic factors in Michigan's Upper Peninsula for at least the next half century, according to a report by Ebasco Services Inc., New York business and engineering consultants. The general tone of the report is contradictory to those few who have foreseen a blighted future for the Upper Peninsula once high grade ore is no longer available.

Much of the report's optimism is based on current studies on beneficiation of low grade ores. The report claims that eventual development of this phase of mining will guarantee a healthy industry. The report covers all natural resources of the Peninsula and is designed to serve as the basis for economic development. Work was initiated by the Michigan Economic Development Commission. Private industry financed the survey, with Upper Peninsula and lower Michigan companies sharing the cost.

Ebasco noted the current low grade developments on the Marquette and Menominee ranges, beneficiation research by Cleveland-Cliffs Iron Co. and Jones & Laughlin Steel Co., and the planned Mineral Research Div. at the Michigan College of Mining and Technology at Houghton. These activities are presented as evidence of the bright future of iron mining.

Copper Range's White Pine development and Calumet & Hecla's dewatering of the Osceola mine are considered to be signs of a continued prosperity for copper mining.. The report modifies its stand on copper somewhat by stating that Michigan copper production profits are largely dependent on market price and Government subsidies. However, amidst the current crop of dim, dark, and dreary forecasts, the Ebasco report presents what appears to be a solid evaluation of the economic health of one section of the country without insinuating impending doom.

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COLORADO Fuel & Iron Corp.'s new pilot plant for test production of char may be another step forward in rectifying the inequalities of nature. The plant is designed to make Colorado coal age several million years in matter of minutes. Colorado coal is something like 80 million years younger than eastern coal. Because of its immaturity it is highly volatile.

The new char plant at CF&I's fully integrated steel mill at Pueblo is really a low temperature furnace which removes part of the excess volatile matter. It produces a low volatile coal or char which can be blended with other coals. Mixing the resultant char with Colorado coking coals improves the quality of the coke.

In the Petit process char plant two gas burners feed 2500 ft per hr of flaming gas into a vertical chamber zig-zagging 50 ft down the center of the tower, where a steady flow of coal is converted into char. About 1 ton of coal per hr is handled by the furnace to produce 1600 lb of char. With the construction of the plant the value of improving western coal can be established over a period of time. CF&I engineers started work on the plant in January of this year with the Koppers Construction Co. of Pittsburgh. Construction was based on plans of the Societe de Technique Industrielle of Paris. The final test of the value of char blending will be use of the material in coke ovens and blast furnaces.

An experimental Hayes retort was built near the present Petit plant in 1942. Results of this earlier work by CF&I played an important part in the development of the char theory and some parts of the old plant were used in construction of the new one.

A. F. Franz, CF&I president, feels that "it is too early to estimate the effect this char plant will have on CF&I's future steel production but completion of the pilot char plant is a significant step in our long range plan to utilize fully the steelmaking resources available to us locally.

"Development of our new Allen mine in southern Colorado, with its intensive mechanization and latest type belt conveyor systems, earlier this year, represented a major step in this program. Large reserves of coking coal have been one of the important factors in the continued program of expansion and modernization of Pueblo mill. Completion of the pilot char plant is merely another part of our continuing search for the best possible use of this vital resource."

The char process dates back to 1908, when Kotara Shimomura of Japan was one of the first to develop the theory of mixing char with high volatile coal. The Daniel Petit process represents one of the more advanced approaches.

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"THEY always put the town on top of the best ore," is an old saying of the mining industry. Thus, many of the great mining towns have had a migratory history. Hibbing, Bisbee, Jerome, and Negaunee are among the towns that have been literally picked up and moved to allow continued mining. Changes in mining and milling methods, economic conditions, and other factors modify pit and mine limits.

But modern exploration methods are eliminating the costly procedure of building a town—and then rooting it up to make room for mining. A recent news item concerning activity at the New Brunswick find in Canada noted discovery of a new electrical anomaly during "preliminary exploration designed to eliminate ground in an area where it had been proposed to lay out the town site" (*Northern Miner*, May 28, 1953). In northern Michigan the test hole at a planned shaft site disclosed an unsuspected orebody and caused relocation of the shaft site, redesign of the mine plant, and relocation of the railroad. With mining costs displaying little sign of reversing the upward trend, mine companies save large amounts of money, time, and labor.

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MEN and animals did most of the work in French mines before World War II. Today, machines speed operations at a rate that might have seemed fantastic to the average miner before the war. Mine cars with up to 2-ton capacity are being replaced with units that carry from 6 to 11 tons. And they need the larger cars to keep up with the tremendous increase in production. Output before the war averaged 5.2 tons per work gang. Certain new machines make it possible for the same group to turn out 300 to 400 tons.

In 1945, when capital was scarce and France still staggered from the German-inflicted devastation, the mining industry drew up a modernization program which called for an investment of some $20 million. Another $53 million went into mechanization in 1949. Plans for further improvements call for an additional $143 million in the next five years.

Typical of the increase in mechanization is the situation in the Lorraine iron mines. Before the war there were fewer than 100 loading machines. By July 1948 the total rose to 230, and to 432 in April 1952, in addition to 40 more on order. At the latter date there were 32 cable scrapers and 13 on order.

Lorraine mines increased production to 32.8 million tons in 1951. By 1958 it is expected that some 53 million tons will be produced annually. The detailed report by the Trade Association of the Iron Mines of France says, "that it would probably have been impossible for the French iron mines to re-equip themselves so rapidly if not for the Marshall Plan, and that without the engineer missions that visited North America their technical progress would have been less immediate."

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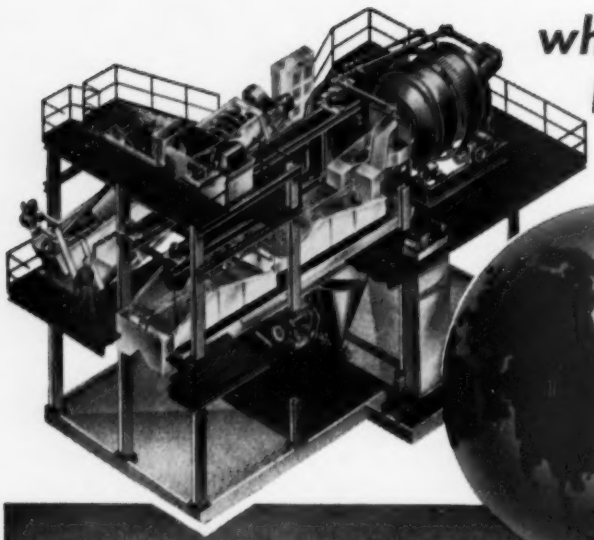
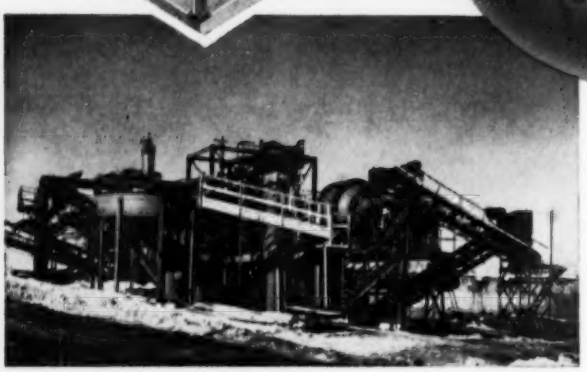
IT'S natural for the average man who makes his living in and around mines to accept what he sees during his daily routine without thought. For him there is nothing unusual about the way he earns his livelihood—and certainly he sees little that can be expressed graphically. In back of his thinking may exist an understanding of the basic importance of what he is doing—but the articulation of this significance must be left to others. A short time ago some 167 members of the Lehigh Art Alliance explored the properties of the Lehigh Navigation Coal Co. with sketch pads, charcoal, paints, cameras, easels, oils, and even folding camp chairs. The traditional artists' smocks were missing. Artists dressed pretty much the way the average mine worker does. Instead of the north light which most artists demand while they work there were hardhats and safety lamps. Divided into groups of nine, they were accompanied by mine inspectors. Most of them descended to the 1029-ft level of the Old Company Coaldale No. 8 mine.

They sloshed through water, crouched to get through low clearances, and saw the mine at work. There were a few bumped heads and snagged clothes, but no accidents. Although the visit was made on Saturday, there were enough employees around to give the artists some authentic material to work with. Some confined activities to the breaker, strip mine, and power plant, but most went underground.

By October, the trip will have resulted in some 500 canvases, drawings, sculptures, and ceramic pieces to be displayed at the Art Alliance's annual exhibition. Previous industries which have been covered are electric power, newspaper, and dairy.





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Mobil-Mills are furnished in five basic sizes and several models with smaller or larger plants varying in capacity from 5 to 275 TPH. Each plant is equipped with a choice of one of the following type separators to meet your particular requirements:

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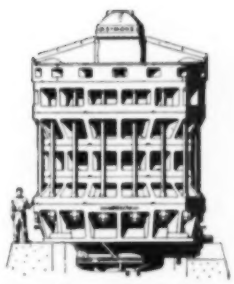
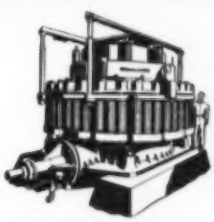
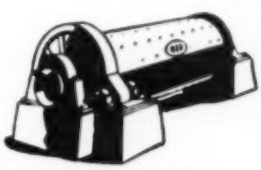


SYMONS Primary Gyratory Crushers

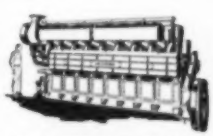


SYMONS Cone Crushers

SYMONS Vibrating Grizzlies and Screens



NORDBERG Grinding Mills



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Kaiser Aluminum and Chemical Corporation imposes a very tough specification on its Nativadad (California) Dolomite Plant—less than 1% silica and not less than 98% dolomite from a deposit of dolomitic limestone intruded by large dikes and sills of high-silica granite!

To produce acceptable kiln-feed it had been necessary to by-pass large dikes and sills or to mine out and discard these high-silica intrusives as waste. "Selective shoveling" made quarrying operations, difficult, costly. At one time, only 38% of the mined material was usable. Beneficiation, too, posed a problem because the specific gravity of acceptable product is within 0.10 of the high-silica waste.

To solve this difficult operating and economic problem, Kaiser installed a 250 tph Heavy-Media Separation plant. Result: A more uniform, low-silica product; better kiln operation, and lower costs all along the line. Typical analyses of end product now show silica approximately 0.3% from a feed running as high as 7.7% and averaging 2.7 SiO_2.

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Treating 4 x ¼" feed with a ferrosilicon-magnetite mixture as the separating medium, this pre-fabricated Heavy-Media Separation plant operates at 2.65 specific gravity. Medium-loss averages well under a half-pound per ton of kiln-feed recovered. Capital costs were minimized by pre-fabricated construction. Operating and labor costs are low.

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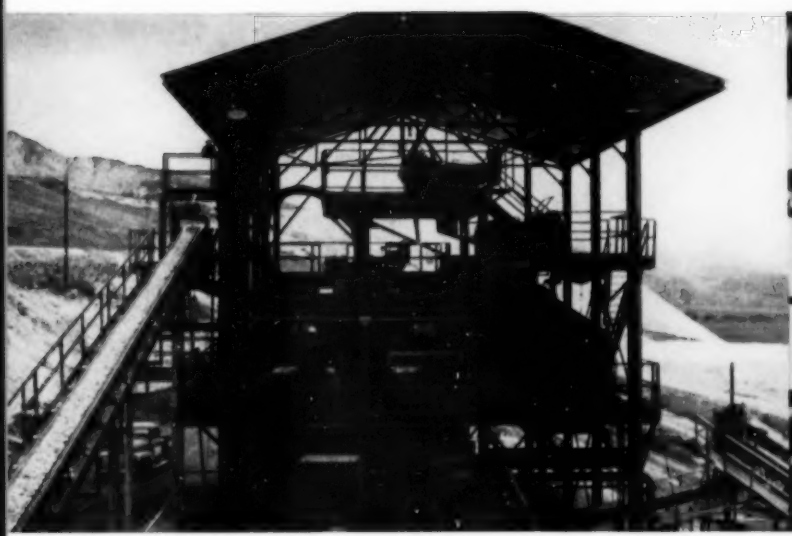

This is but one of many examples of non-metallic minerals now being beneficiated by Processes and Reagents offered by Cyanamid. Quickly and at low capital cost, you may be able to improve output, cut costs or make "sub-marginal" deposits workable through accurate, low-cost concentration employing one of these processes.

Cyanamid offers a choice of processes covering a full size-range: Heavy-Media Separation, 6 x ¼"; Dutch States Mines Cyclone Separator, ⅜" x 65 mesh, and Froth Flotation, 65 mesh x 0. Test results, design data and operating experience are available to assure predictable performance in minimum time at the lowest cost.

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☐ *Send a copy of "Mineral Dressing Notes #19– Heavy-Media Separation Processes for Mineral Concentration"*

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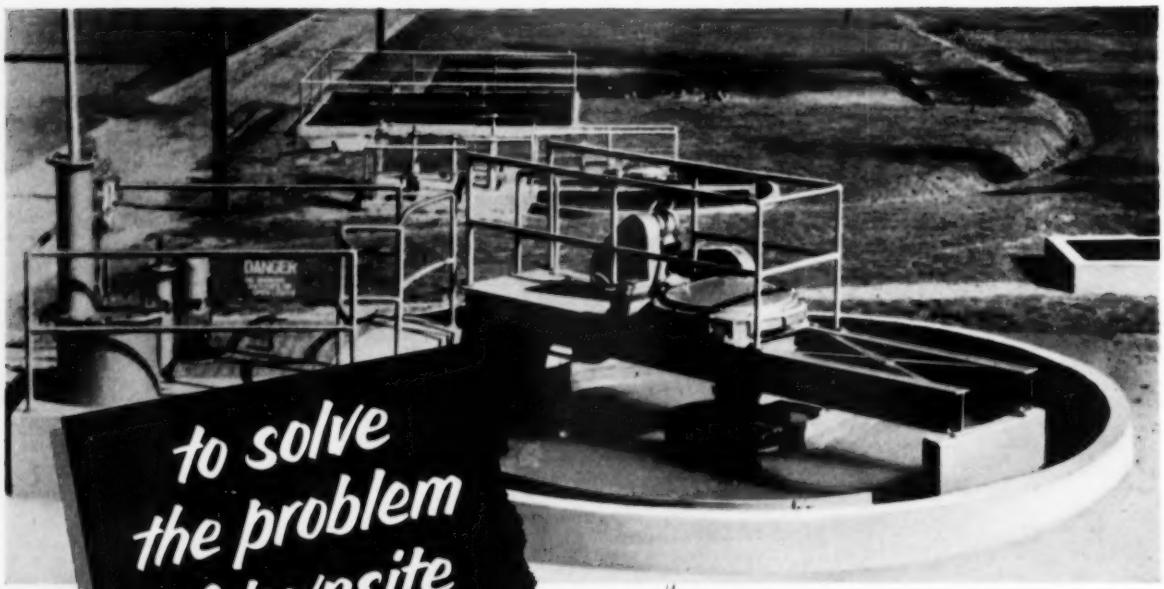

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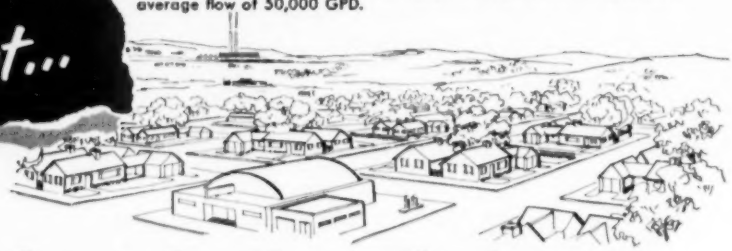

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Because of its completely mechanical action, the Clarigester gives compact and highly efficient operation. Clarification and scum removal take place in the upper compartment, homogeneous digestion and sludge collection in the lower compartment. A special one-way seal prevents the passage of gas or sludge liquor upward. Heating coils may be installed to promote optimum digestion temperatures with hot water usually supplied by a small boiler.

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Allis-Chalmers know-how and equipment have been playing a leading role in the processing of taconite. A-C research laboratory tests, along with pilot plant operations and field work, have revealed valuable data on the processing of low grade iron ore. Crushers, vibrating screens and grinding mills furnished by Allis-Chalmers are already helping to solve the problem of taconite processing on the Mesabi range.

This *unsurpassed* background and experience on taconite, as well as A-C's many years of successful accomplishments on other ores, is available to you when you call an Allis-Chalmers representative. Phone the A-C man nearest you today, or write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-2997

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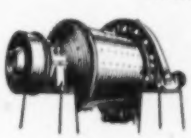

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Sales Offices in Principal Cities in the U. S. A. Distributors Throughout the World.

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UNITED PRESS PHOTO

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Hoover Dam is an outstanding example of the many large construction projects which Hercules explosives have helped to build. The use of explosives on such projects calls for thorough understanding of the rock formation, selection of the correct explosives to shoot the rock, and adequate facilities to supply explosives on schedule. Our Contractors Division has complete technical and cost data on the use of explosives in any type of construction. Hercules also has service facilities to help you in solving mining, quarrying, and petroleum problems involving explosives.

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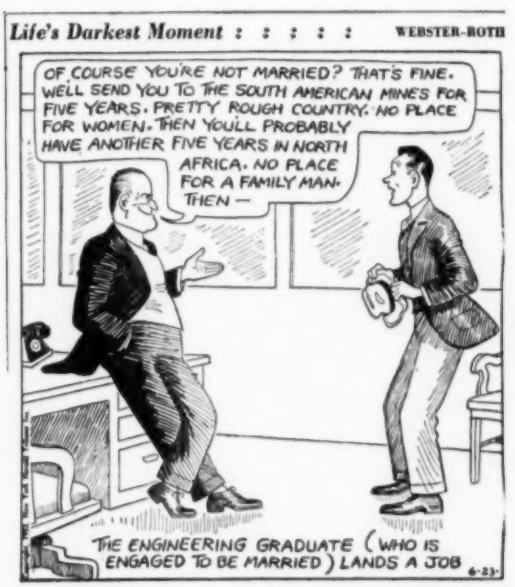
XR53-3

Drift of Things

THE Implication Is Wrong—Doubtless many mining men got a smile out of the accompanying Webster-Roth cartoon when they saw it in their newspapers recently. We hope it will not mislead and discourage too many young men who are contemplating entering one of our mining schools. Few are the mining camps nowadays which are in such "rough country" that women are barred. Most foreign mining camps welcome the right kind of young bride. Our own bride, whom we took to a Canadian mining camp 39 years ago, never appeared to regret the experience; she found several other interesting young women there, many of whom still remain friends to this day. But the girl has to be carefully selected, and a young mining engineer should be especially careful not to make a mistake here.


Life's Darkest Moment : : : : :
WEBSTER-ROTH
OF COURSE YOU'RE NOT MARRIED? THAT'S FINE. WE'LL SEND YOU TO THE SOUTH AMERICAN MINES FOR FIVE YEARS. PRETTY ROUGH COUNTRY. NO PLACE FOR WOMEN. THEN YOU'LL PROBABLY HAVE ANOTHER FIVE YEARS IN NORTH AFRICA. NO PLACE FOR A FAMILY MAN. THEN —
THE ENGINEERING GRADUATE (WHO IS ENGAGED TO BE MARRIED) LANDS A JOB
6-23-

Courtesy *N. Y. Herald Tribune*

Most permanent camps of the larger companies in foreign countries provide attractive living conditions. They have to or they could not get enough or the right kind of men for their professional staffs.

The cartoon also implies that the young man in question has had a rather hard time in finding any job at all, so is considerably perturbed about what he is offered. Nowadays, practically every engineer has his choice of many openings, and he doesn't land them—the employer lands him. If he is the right kind of chap, and has picked out the right girl, some mighty interesting years are ahead of him in "the South American mines." Later in life he and his wife will join that great American mining fraternity that gets together at AIME Annual Meetings and on other similar occasions, and finds friends from all over North and South America and a few from beyond the seas as well.—E. H. R.

IN *U. S. News & World Report*, July 10, Dr. J. Robert Oppenheimer, one of the best-informed men on the atomic bomb, gives causes and effects of cold war atomic preparedness, as related to the release of atomic information to the public. After describing the cold war program, he gives the status of the armament race, "As for the U.S.S.R., . . . it has produced three atomic explosions, and is producing fissionable material . . . I think that the U.S.S.R. is about four years behind us. And I think that the scale of its operations is not as big as ours was four years ago. It may be something like half as big as ours then was. This is consistent with the facts known to us. It has not been proven by them, by any means.

"This sounds comfortably reassuring. But in order to assay what it means . . . we have to know something of what it is that they are four years behind . . . and what it means to be half as big as we are.

"The very least we can conclude is that our 20,000th bomb, useful as it may be in filling the vast munitions pipe lines of a great war, will not in any deep strategic sense offset their 2,000th.

"We may anticipate a state of affairs in which two Great Powers will each be in a position to put an end to the civilization and life of the other, though not without risking its own. We may be likened to two scorpions in a bottle, each capable of killing the other, but only at the risk of his own life.

"In this prospect, surely, we shall need all the help and wisdom and resourcefulness we can muster.

"We do not operate well when the important facts, the essential conditions, which limit and determine our choices, are unknown. We do not operate well when they are known, in secrecy and in fear, only to a few men.

"Many arguments have been advanced against making public this basic information. . . . One is that we might be giving vital information to the enemy. My own view is that the enemy has this information. It is available to anyone who will trouble to make an intelligent analysis of what has been published. Private citizens do not do this; but we must expect that the enemy does. . . . It is also my view that it is good for the peace of the world if the enemy knows these basic facts—very good indeed, and very dangerous if he does not.

"As a first step, but a great one, we need the courage and the wisdom to make public at least what, in all reason, the enemy must now know: to describe in rough but authoritative and quantitative terms what the atomic armaments race is. It is not enough to say, as our Government so often has, that we have made 'substantial progress'."

The last real effort to follow the program Dr. Oppenheimer has suggested was the report, *Atomic Energy for Military Purposes*, by Henry D. Smyth, published in 1945. This book was the only authentic compilation of information on atomic developments. Now, after a lapse of eight years, one of the men that played a leading role in the development of this instrument has expressed his deep concern over the misinformed public.

Charles M. Cooley

Experts Take A Look At Shaft Sinking

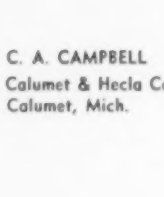
A Panel Discussion by —

C. W. NICOLSON
Chairman
Asst. Manager
North Range
Mining Co.

P. D. PEARSON
Manager
Caland Ore Co. Ltd.
Steep Rock, Ont.

J. D. McAULIFFE
General Operating
Engineer
M. A. Hanna Co.
Iron River, Mich.

C. R. SUNDEEN
Superintendent, Maas Mine
Cleveland-Cliffs Iron Co.
Negaunee, Mich.



C. A. CAMPBELL
Calumet & Hecla Copper Co.
Calumet, Mich.

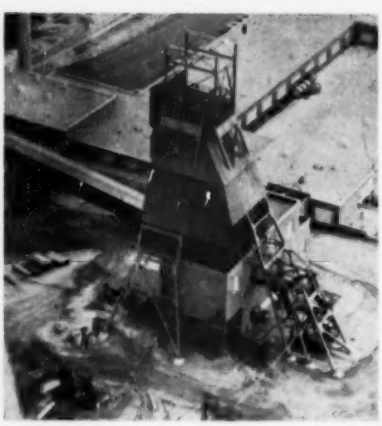
SHAFT SINKING SYMPOSIUM *is a weighty term that could mean any number of things. However, in this case it has been possible to utilize the transcription of the Annual Meeting Session of the same title and present it in much the same manner as the experts on the panel presented it to their audience Wednesday afternoon, February 18, 1953, at the Los Angeles Statler Hotel.*

This program was first conceived and presented at a meeting of the Upper Peninsula AIME Section in 1952 as a panel discussion among mining executives of Michigan's Upper Peninsula iron and copper mines. These mines have been active during the post-war years opening up new properties and re-equipping operating mines, and all this new work, requiring shafts and hoisting facilities, placed the discussion group in a uniquely informed position on the kinks and problems of shaft sinking.

Pertinent subjects discussed are general plant installation, sinking with caisson, drilling in shafts, excavation of both vertical and inclined shafts, concreting, timbering, and roof bolting. Here, the experts discuss the problems encountered in putting a shaft down and give many seldom heard facts they have all had to face on these jobs.

Selecting from over fifty slides, MINING ENGINEERING *is passing on to you the Shaft Sinking Symposium that was rated one of the most important Mining Subdivision sessions at the 1953 Annual Meeting.*

As a prologue to shaft sinking, it is essential to understand the trends in surface plant construction in Northern Michigan. Severe winters lead to plant designs incorporating as many functions as possible under one roof, with outlying structures connected by tunnels. Above, left, is the Mather "B" shaft of the Cleveland Cliffs Iron Co. at Negaunee, Mich. The large building, left center, houses the offices, change house, machine shop, lamp room, warehouse, and mine rescue training facilities. The structure is connected to the head frame by a service tunnel. Directly behind the shaft is the hoist house, also connected to the main building and shaft by a tunnel. Trestle housing to the right is conveyor system for stockpiling winter production. See ME July 1953.



Photograph left is a close-up of the Mather "B" headframe, showing the use of foot sheaves. These foot sheaves have two principal advantages over the more common arrangement. Cage and skip sheaves can be mounted in the most desirable position on headframe, and do not require that main hoists be skewed. This permits hoists to be installed in a straight line, giving clean construction in the engine house. Note the brick structure around base of headframe, which contains feeders and crushers. Picture above is the Sherwood mine, Inland Steel Co., Iron River, Mich., again showing buildings grouped around the headframe. Idler sheaves and stands are used for cage and skip ropes. This is common in Upper Peninsula headframes.

J. D. McAuliffe, M. A. Hanna Co., discusses sinking through water-bearing overburden:—

The Cannon Shaft southeast of Iron River, Mich., has a site with 140 ft of sand, gravel, and clay overburden—all water-bearing except for the upper 15 to 20 ft.

Concrete drop-shaft method with provisions to switch to a pneumatic caisson if necessary was selected to excavate through the loose material. The Foundation Co. of New York took the contract to put the shaft down to the rock ledge and seal it off.

Drop-shaft at the cutting shoe was 15½x20 ft with 5½-ft walls. Size at collar was 18x22½ ft to allow steel sets to be installed in proper position even if caisson was up to 15 in. out of plumb.

This is the sequence of operations from breaking ground until the caisson ledged in:

Aug. 23 to Sept. 15, 1951—Construction cutting shoe and pouring vertical concrete wall to 10 ft.

Sept. 15 to Dec. 8—Sinking with clamshell with drop-shaft full of water. Progress to 87-ft depth was at the rate of 8 ft of excavation and concrete per 10 working days, one 8-hr shift.

Dec. 8 to April 1952—Shaft pumped out after encountering boulders, so men could work under cutting edge and break large rocks. Rate of advance to 108 ft was 4 in. per 8-hr shift. Quicksand run at 108 ft impeded progress which was 1.6 in. per shift to the 114 ft level.

April 1 to May 1—Preparing deck for pneumatic caisson and installing equipment.

May 1 to Aug. 25—Sinking under compressed air from 114 to 142 ft. Air pressure was 37 psi initially and finally increased to 45 psi.

Aug. 25 to Sept. 8—Concreting and grouting seal to ledge.

Sept. 8 to Oct. 9—Tearing out compressed air deck and associated equipment.

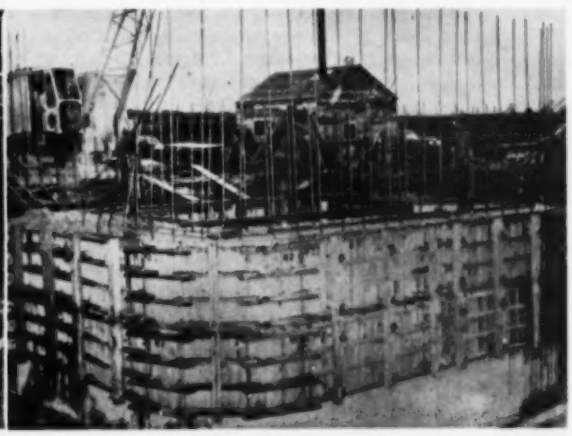
Oct. 9 to Oct. 15—Excavating below caisson with paving breakers.

Oct. 15—Rock under northeast corner of caisson collapsed permitting a sand run.

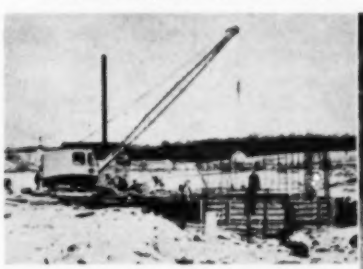
Oct. 15 to Jan. 27, 1953—Repairing rock break with grout, sheet piling, rock bolts and inner concrete wall.

Jan. 27 to date—Sinking in rock to 400 ft.

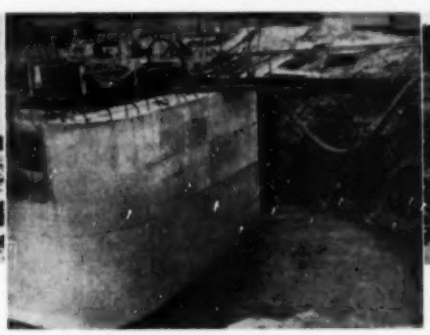
Form for cutting edge of drop shaft in 15-ft excavation at shaft site. Lower left side is 1-in. steel plate that forms the actual knife edge. The caisson extends vertically from the outer edge of the form. A 48° incline to the inside of the concrete forms the remainder of the cutting edge. Staging shown was for the ¾-yd Koehring dragline used to excavate the sand and gravel from the caisson.



Drop shaft after sinking was in progress. Note water running out of clamshell in center of shaft. Concrete was poured in 8-ft lifts with plywood multi-use forms. While sinking in this manner, advance was about 8 ft in 10 days, i.e., concrete and excavation. The drop-shaft has 5 ft 6 in. walls at the bottom, diminishing to 4 ft 3 in. of reinforced concrete at the collar. The taper is on the inside.

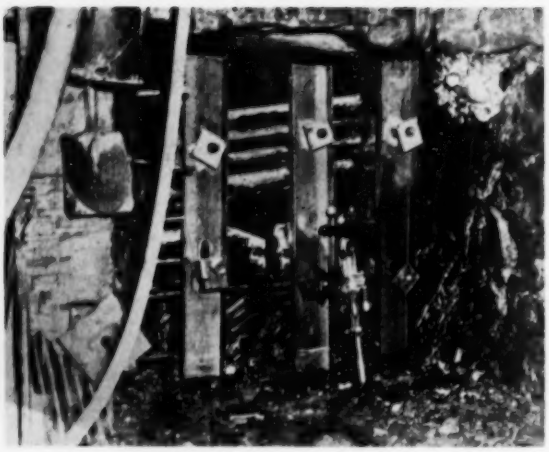


Packing effect from the crib supporting shovel caused caisson to lean to the right. This was corrected by selective excavation and shoring the caisson up on the side opposite the shovel. Final position of the caisson was almost plumb.



Closeup of caisson after change-over to pneumatic method at 114 ft. Note air bubbles escaping from pool on the right. It was believed that this aided the settling of the drop-shaft by keeping the surrounding sand agitated.

As the rock ledge was approached at 142 ft the caisson operating pressure built up to 45 psi and friction was high. Settling rate was increased by adding 400 tons of iron concentrates and by dropping pressure suddenly when chamber was empty.



Following the failure of the rock under the caisson, the area was grouted and sheet piling was driven horizontally under the drop shaft. More grouting was done behind a temporary concrete retaining wall in the bottom of the shaft. After the final grout set, the temporary wall was removed and the material chopped away 18 in. inside the inner face of the caisson and for 6 ft below. As shown in the photograph, rock bolts were then used with channels to hold corrugated sheeting in place against the exposed face. This was sealed off with an 18 in. concrete wall all around the bottom of the caisson.

J. D. McAuliffe, (Speaking of Cannon Shaft, *M. A. Hanna Co.):* Now, here are two sets from the Cannon Shaft erected, see photograph at right, with powder sticks placed through wire fencing just to show the new drill crews how it was hoped their round would look. . . . These new shafts are more of the broad rectangular type than of the long, narrow ones we from the West are familiar with. The type of cut since the advent of the mechanical mucker has been more toward pulling a full round at one time than the old, bench-type cut. . . . In drilling these full rounds either a V-cut or a burn is used with 70 to 78 holes, and it looks as if the shaft sinkers have decided among themselves that 2 to 2½ ft is the burden. Two shafts being excavated now are using 6 and 7 hole burns. In these two cases there have been no wrecks, though there was some gunning action. . . . Formations break with fairly light charges and fragmentation is good.

Hole diameter has been 1½ to 1⅝ in., depth 4 and 5 ft. Recently, in one shaft, changing from 7 to 6 ft saved a steel change and gave greater advance, even with the additional blasting time. Drilling equipment has generally been a 55-lb jackhammer, one shaft used a 75-lb machine. Light, fast hitting machines with ⅞-in alloy drill rods with intraset bits have not been too popular in the shafts, but one shaft is using them.

Tungsten carbide bits are popular. The intraset or detachable bits are being used. The trend with detachable bits is going to downstroke rotation. This has not caused a great loss of drilling speed and the two shafts that have used this report diminished thread wear. But side by side with one of these shafts in the granite is a shaft using a detachable carbide bit—they still have upstroke rotation. So it all depends on the local conditions. The footage per bit is reported 300 ft in granite, 690 ft in iron (formation), 492 ft in quartzite, and we have no information on shales right now.

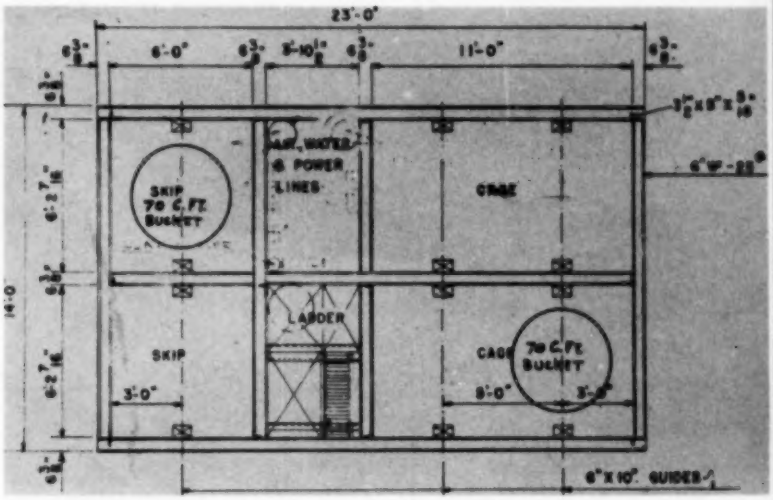
Size of crews has varied between 6 and 12 men, with the shift boss on each shift extra. This generally depends on the number of machines they want to use . . . . There is no particularly special equipment used. . . . We have not used any drill jumbos in shaft sinking, but it would offer many advantages if we could get a jumbo that could be set up faster than jackhammers.

C. R. Sundeen, (Speaking of Negaunee Shaft, *Cleveland-Cliffs Iron Co.):* Drilling was with conventional hammers—55 or 60-lb class—hand held, with carbide tipped, cross-bit, intraset steel. Starters were 1⅜ in. . . . Drilling a very small hole probably gained some speed. Rock was greywacke, quartz, and slate. Average drilling time was about 3 hr for 65 to 75 holes about 7-ft deep.

Eight men in the crew, plus a shifter, drilled the entire round at one time. The header had 24 hoses —12 water and 12 air—giving us a few spares. The men called this the spaghetti machine. . . . Most of the powder used was 80 pct gelatin . . . . with another percentage fragmentation was poor, particularly for use with a hydro-mucker. . . . One and one-eighth sticks were used because the hole was collared with 1⅜-in. bit. Drilling and loading time was a little better than 3 hr.

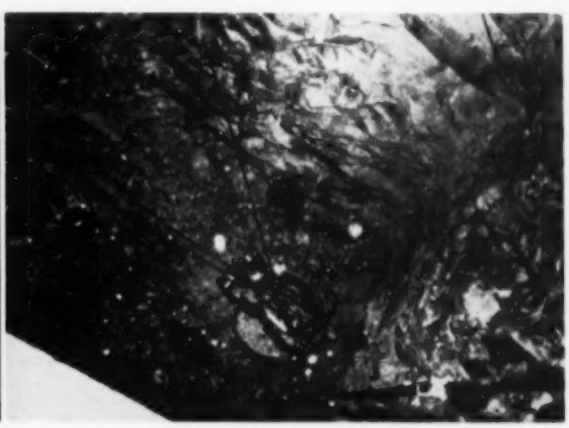
Chairman C. W. Nicolson: There were a few statistics on drilling that Fred Denton *(Oliver Iron Mining Co., Ironwood, Mich.)* was going to give. Twelve 50-lb jackhammers, using 1 5/16-in. carbide detachables, drilled 75 holes per round. Average break was about 6½ ft deep, using a burn cut, average overbreak was about 18 in. The shaft bottom was carried 20 to 45 ft below the bottom set, sinking in granite. This was with 12 men and a boss on each shift.

C. R. Sundeen, Cleveland-Cliffs Iron Co., describes mechanical shaft mucking:

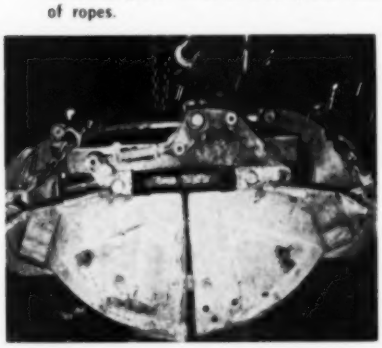


LEFT—One typical shaft plan using two skips or buckets and two cages with ladder road between. Plan of shaft is particularly important when using mechanical mucking equipment. The ladderway in the middle provides a place for installation of the mucker, hydraulic pump unit, tuggers, etc. The ladder and pipe compartment between the cage and skip compartments is also a safety feature. In case of a shaft wreck at least one of the hoisting facilities is available. RIGHT—This is a standard or high-head hydro-mucker as used in the Negaunee shaft. In this case the bucket shown is hoisted directly to surface.

A low-head hydro-mucker commonly used in Upper Peninsula shafts. The hydraulic rams are mounted horizontally to lower the center of gravity of the clam, giving it more stability. The mucker is shown dumping into the bucket. Note the four ropes to the right, two control the hoist for lowering and raising the dipper, and other two open and close the jaws. In some shafts, one man controls both sets of ropes.

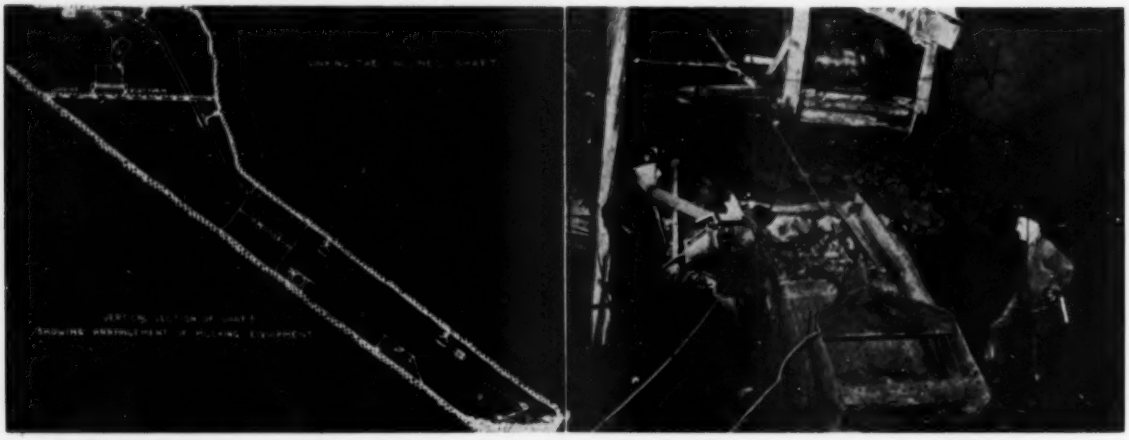


The low-head mucker looking down the shaft as it is dumping. Fragmentation is an important factor in the operation of the hydro-mucker, for a large chunk caught in the jaws will let all the fine material fall out. We have not had any serious accidents with miners getting caught in the jaws. Also we can find no record of injury from the bucket swinging back and forth.



LEFT—View of low-head hydro-mucker in the shop. The horizontal hydraulic ram can be seen. More particularly when excavating in granite, it is necessary to reinforce the clam with a hard material such as Stellite. Abrasion is severe in many cases, and the mucker has to be built up from time to time. RIGHT—Two men handling the ⅜-yard clam to dig in muck pile on shaft bottom.

C. A. Campbell, Calumet and Hecla Copper Co., discusses methods used in sinking inclined shafts in Michigan's copper country:—



IN THE COPPER COUNTRY of the Upper Peninsula, north of the iron mining district, the ore bodies all dip 32 to 45°. Mining only 1 pct copper, all deadwork must be avoided, so the shafts are put down in the footwall close to the ore body. LEFT—Vertical section through a shaft showing the monorail and ramp system for mucking an inclined shaft. This section is part of an operating shaft with a 10-ft rock pentice left below the last station to protect shaft workers. The relative position of the various equipment is clearly indicated, 8-in. I-beam monorail, scraper ramp, slusher hoist, and the bucket dumping into a car at the station. RIGHT—The photograph shows a close-up of the slushing ramp and the scraper bringing rock into the box behind the inclined ramp. When this is filled the bucket on the monorail is positioned approximately where the scraper is shown in the photo, and an air cylinder (just to the right of the man on the left) raises the scraper pocket and dumps it into the bucket. The monorail skip is pulled up to the transfer point. Slushing is done with a three-drum hoist. This is a 9x22-ft shaft with two skip compartments and a ladderway.

SHAFT SINKING is planned so that there is no rush. This makes it possible to use a minimum crew with maximum efficiency. There are four workmen and a foreman on the crew with rock advance averaging about 3½ to 4 ft per day. The drilling crew also installs the pins for the 8-in. monorail.

Inclined shafts in the copper country are sunk raw, and timber is installed from the bottom up. Dividers are 10x10-in. timber on 5-ft centers, blocked in place, with a good hitch about every 60 ft. Sleepers are 8x14-in. fir with 90-lb. skip rail.

LEFT—Looking down shaft, showing details of timber installation and the type of hanger used for the 8-in. I-beam. Two rock bolts and a chain hanger are used to carry the rail. RIGHT—Bucket shown on monorail mount is used when timbering. This bucket replaces the mucking tray because it is easier to remove material. The Copper Range of the Michigan Upper Peninsula is the only district using this mucking method in inclined shafts.

Riddell Shaft Mucker

According to **J. D. McAuliffe**, the Riddell Shaft Mucker has not been used in any of the Upper Peninsula shafts, but he gives the following data on the machine:

1. The Riddell Mucker has been adapted to shafts of the following sizes as well as those of intermediate dimensions.

   Smallest, rectangular,

outside of timber, 7 ft x 13 ft
Largest, rectangular,
outside of timber, 16 ft. 4 in. x 30 ft. 8 in.
Smallest, circular, neat outside, 16 ft diam
Largest, circular, neat outside, 24 ft diam

2. Types of Design:

(a) Two general designs of carriage are in popular use.

(1) A carriage, light in design, equipped with guides to accommodate the shaft runners, permitting the removal of the carriage from the proximity of the blast.

(2) A carriage, heavy in design, capable of withstanding the impact of blasting.

(b) Two special designs have been featured that permitted the clamshell bucket to serve all parts of a shaft without casting.

(1) For larger circular shafts an additional circular track has been introduced, permitting the conventional mechanism to revolve.

(2) For large rectangular shafts a secondary cross motion has been incorporated into the carriage, allowing the hoist motors to change position.

In all cases the track frame is designed to withstand the impact of blasting. In many instances, the track frame serves as a blasting set as well as a platform for timbering.

3. Monthly Penetration Records:

Case I

Progress, 309 ft in 30 days—3 shifts per day
Size, outside of timber, 6 ft 11 in. x 17 ft 2 in.
Number of men in shaft, including supervision, per day—19
Monthly advance per man—16.26 ft
Cubic yardage per man shift, measured in place—2.38 cu yd

Case II

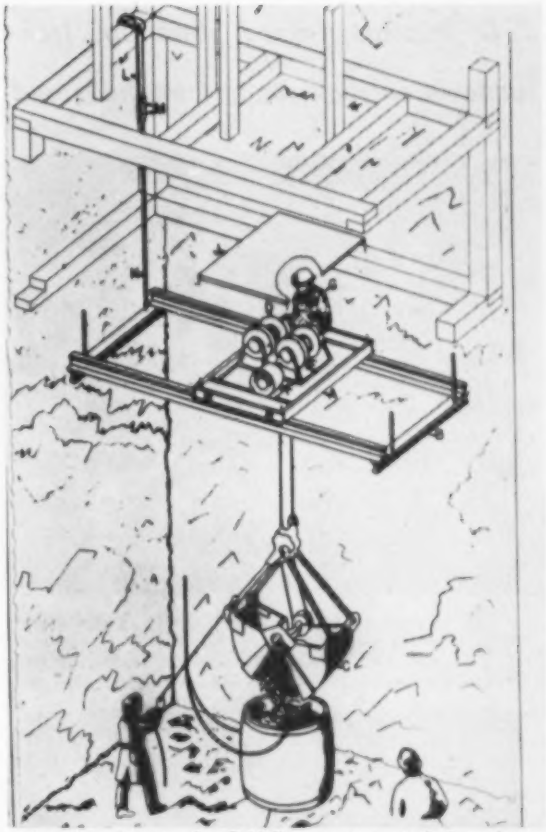
Progress, 284 ft in 30 days—3 shifts per day
Size, outside of timber, 6 ft 10 in. x 17 ft 8 in.
Number of men in shaft, including supervision—13
Monthly advance per man—21.84 ft
Cubic yardage per man shift, measured in place—3.26 cu yd

4. Capital Costs:

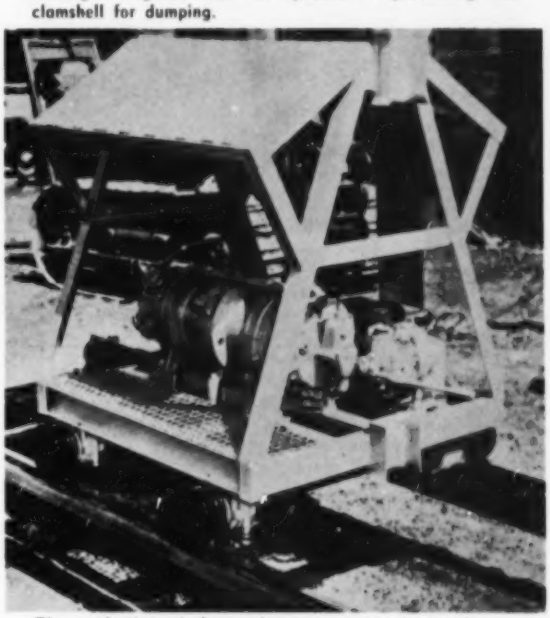
Carriage, track frame, and $\frac{3}{8}$-cu yd clamshell, $6000 to $7400, depending on size of shaft and design selected. Approximately $4300 to $4800 of this equipment can be reclaimed for use in the mine.

5. Royalty:

Per cu yd for use of design—36¢ as measured in place

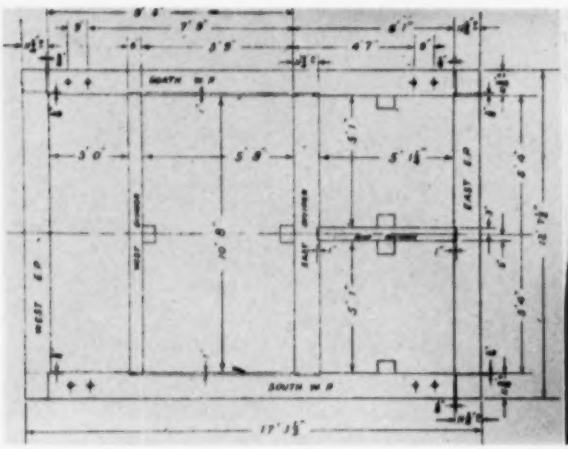


Isometric drawing of a Riddell suspension attached to the timber several sets above and hanging below the last set. The clamshell is carried back and forth across the shaft by the carriage, digging and dumping into the bucket. Men holding a tag line aid the operator in positioning the clamshell for dumping.

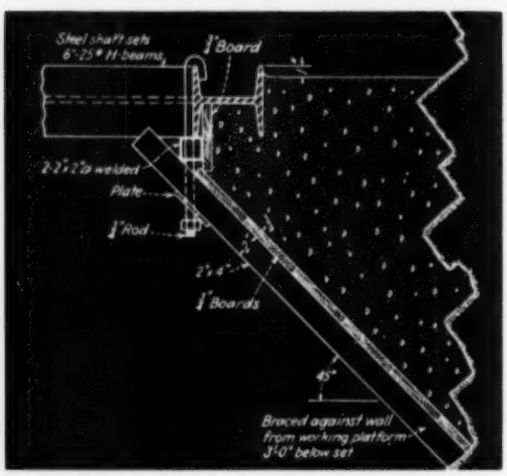


The mechanism of the mucker is constructed several ways. The photograph shows a carriage that can be raised with the main hoist when blasting or timbering. Note the slides for the shaft guides. It has been reported that this type of shaft mucker with a single hoisting line has handled 219 cu ft of rock per hour.

J. D. Pearson, Inland Steel Co., Iron River, Mich., gives a rundown on rock support methods and concreting practices:



LEFT—Layout of older type shafts in the Upper Peninsula using timber. Often acid water, shortage of steel, and cost influence the use of timber. In this case, the ladderway is located on the side, whereas, newer shafts have the ladderway in the center. RIGHT—View of staging and blasting set for placing timber and protecting timber when blasting. Note safety chains on the right, as well as the cable hangers. Staging can be lowered with chain blocks, cage, or tugger.



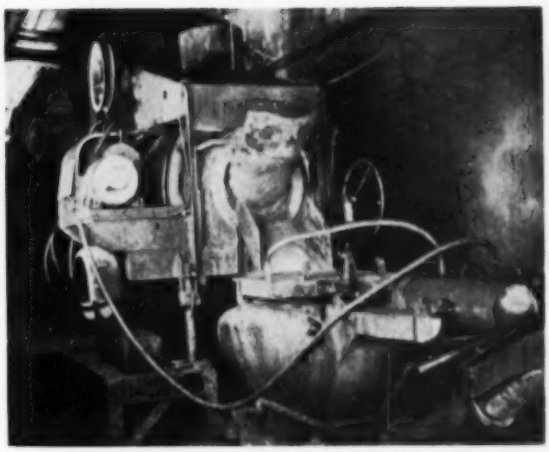
Section through water ring used in Michigan shafts. The rings are usually installed every second or third set with a small diameter pipe put down in the corner to carry the water from ring to ring. Drawing also shows the simple method of forming. RIGHT—Spout used to pour water rings. Note the dead end section of pipe below elbow, an innovation designed to eliminate wear at this point. Concrete is dropped down the pipe as much as 2500 ft from surface, and on occasions, the regular elbow becomes red from the heat of friction. The dead-end pipe seems to act as an air cushion to reduce this problem.

Rock Support Practices

1. Steel sets—6-in., 20-lb H-beams.
2. Timber sets—12x12-in. and 12x8-in. fir.
3. Pre-cast concrete dividers.
4. Lagging:
   a. 2 and 3-in. plank, hemlock or fir.
   b. Corrugated sheet iron.
   c. Pre-cast reinforced concrete slabs made from expanded slag aggregate.
5. Bearing sets.
   a. Three 12x12-in. beams for timber shafts.
   b. Three 10-in., 40-lb I-beams for steel shafts.
6. Blocking sets.
   a. Bags of wet cement supported by reinforcing rods doweled into corners of shaft.

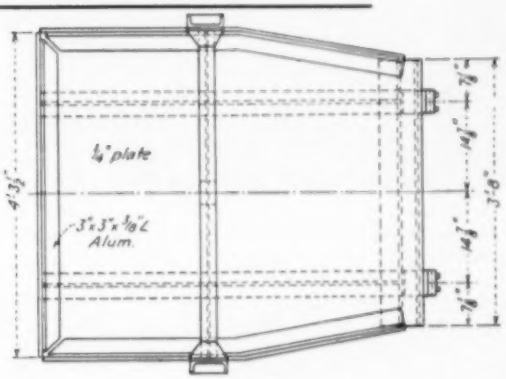
b. Every second or third set sealed with concreting.
c. Wooden wedges or blocks.

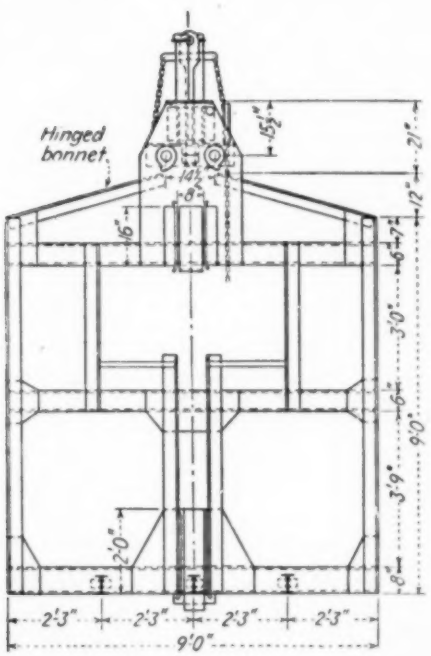
7. Supports between sets (studdles).
   a. Angles, 6x6x½-in. on 6-ft centers.
   b. 12x12-in.—5-ft fir timbers and hanging bolts.
8. Placing sets.
   a. Good ground—place two or more sets continuously using blasting set as support.
   b. Poor ground—Work off muck pile 6 to 10 ft below last set.
9. Blasting sets.
   a. Fir timbers or steel beams with rail stiffeners.
10. Staging.
    a. Four chain blocks and safety chains supporting blasting sets.
    b. Tugger with sling and safety chains supporting steel or wooden set.
11. Station sets.
    a. 18 ft from bottom set to top of cage opening to allow for a 30-ft rail.
    b. Roof bolting to support shaft station roof.

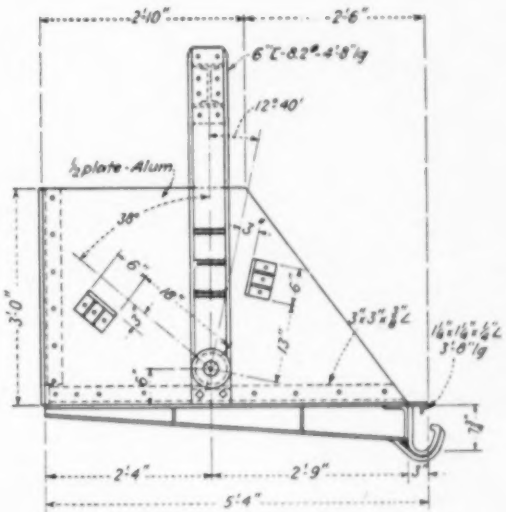


Typical pneumatic type placer for pumping concrete down into shafts of the Iron Range. This setup includes a mixer and placer, but often ready-mix concrete is purchased from a local merchant. The concrete so placed usually gives a minimum strength of 3500 psi.

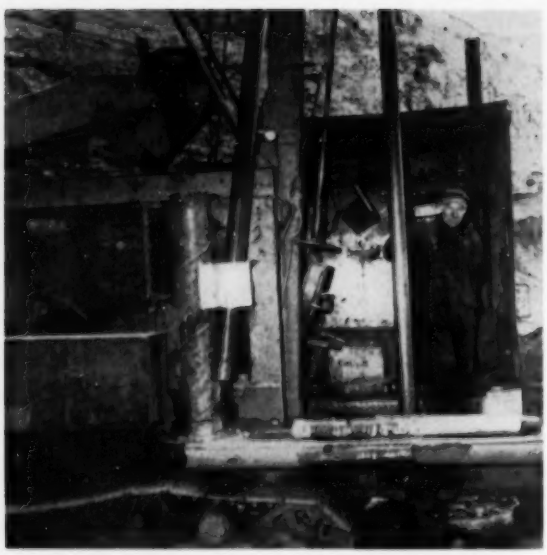
In addition to methods already described for mucking shafts, this system was used in the Mather "B", Negaunee, and is now being used in the Cannon shaft at Iron River. The mucking tray and sinking cage shown are combined with a ⅜-cu yd hydro-mucker to speed up operation. The tray is dumped into a 2¼-cu yd car on the cage. While the cage goes to the collar for dumping, the crew is filling the tray. This increases the operating time of the clamshell. As the tray is raised for dumping, the hooks to the right engage the two bars just above the center divider on the cage, forcing it to tilt up.







Safe Blast Hole Drilling



Moving parts on this drill are enclosed by a gate which is also interlocked with the switch. Note the holder to secure bailer while moving.

Hazards arise from vibration loosening sheaves and braces overhead. Safety chains are one means of prevention, and this steel plate over the operator also provides protection from falling parts.

ALMOST all the hazards productive of accidents are present in churn drill operation—exposed electrical cables, open machinery, moving parts located overhead, exposure to weather, and movement of heavy machinery—all are part of the job. But, a check list of danger spots and full use of countermeasures will produce maximum safety here, as on any other operation.

Safety devices can be a first step. Chains and cables will prevent overhead parts such as sand line sheave, braces, and stem guides from falling if loosened by vibration. Nuts can loosen too, and one company recommends castellated nuts with cotter keys for all bolts over ¾ in. located above the operator.

Moving parts, gears, and drives are a hazard while oiling and making adjustments. A steel gate, as shown in the photograph, is one solution. Interlocking the main switch with the gate provides still more protection.

Climbing the mast to lubricate or make repairs exposes men to falls, but cages and platforms can offer more safety, and grab irons and steps should be installed. Bad weather makes lubrication of sheaves dangerous, and it may be neglected. One company uses remote lubrication through ⅜ in. Neoprene high pressure hose. Hose is reinforced with wire and slack allowed for sheave movement. Worn friction means danger during bailing; one company remodeled parts for easy repair, another finds chain-driven hammer reels a big improvement.

Personal protective equipment can prevent an injury when all other safety measures have failed. Hard hats are especially essential for protection from falling rock near high faces, and hard toed shoes offer protection from dropped pipe, bits, and tools. Goggles and respirators may be necessary in some locations.

Heavy leather faced gloves protect hands against broken wire in cable handling, and some companies require helpers to wear lineman's rubber gloves covered by leather ones when handling power cables. Power cable tongs are a must when handling 3-conductor cable.

Regular inspection by drill crew, mechanical, and electrical departments pays off in safety as it does in maintenance results. Helpers should make daily checks for parts loosened by jarring and vibration, and drillers should check drill line, sand line, brakes, clutches and related equipment. Cables wear at stem connection, and rewrapping at scheduled intervals is best protection here. Monthly inspection of power cable and grounding by electrical department is another must.

Churn Drill Operation Hazards Arise From:

Equipment

Working Area

Operating Practices

These are the Solutions

Safety Devices

Maintenance & Inspection

Protective Equipment

Good Housekeeping

Safety Training

Repairs and adjustments which can be made by the driller and helper should be specifically listed, and no repair work should be done without opening the main switch and tagging or locking it out.

Housekeeping is driller's responsibility. Some points to be covered are: tools put away; holes covered; bits and pipe laid flat, not leaning against drill; platforms free of dirt, ice, and snow; power cable neatly coiled; and water drainage away from working area, with ditches dug if necessary.

A safe drill move requires close cooperation between driller and helper, particularly in keeping road clear, power cable free, and signalling the move. Moving parts should be secured, and if it is necessary to lower the mast, there should be supervision. The route may be checked so high tension lines that come within 10 ft of the mast may be deenergized, and so that maximum safe grade, often stated as 30 pct, is not exceeded.

New hole location must be checked for proximity to crest and to holes still carrying explosives. A safety belt and line are used if working near a crest. A good set-up means solid blocking, and if cribbing is used that should be solid, too.

Training leads to safe working habits, some points to follow here are: (a) never open main switch under load, in an emergency throw out clutch or push stop button first; (b) before ascending the mast stop motor, disengage clutch, and lock brakes; (c) before working inside frame shut power off and blockwalking beam; (d) never pass under drill or work under raised walking beam; (e) observe all blasting rules, always take shelter.

Further details on the lubrication system mentioned, and on safety cables or chains for overhead parts are available from the National Safety Council. Photographs are courtesy of Steep Rock Iron Mines Ltd., with the exception of the top picture, opposite page, from M. A. Hanna Co.

Safe working habits are vital part of any safety program—one rule that should be emphasized—never walk under the drill or the walking beam when they are in the raised position.

SAFETY—HIGH AND LOW: This helper can climb and grease sheave safely. Each drill should have a safety belt to be worn while on the mast. Grab irons and steps should also be welded or bolted to the mast. RIGHT: Blocking or cribbing, with timber in good condition and firmly placed, is necessary to keep machine from swaying on the jacks. Handling the timbers and jacks is another spot for safe working habits, to avoid sprains and strains.

British Producing Germanium From Flue Dust

BRITISH success in extracting significant quantities of germanium from gas works flue dusts has been one of the prime forces in promoting similar research in the United States. Pittsburgh Consolidation Coal Co. and Pennsylvania Coal & Coke Co. are two of the larger U. S. firms with germanium from flue dust research programs.

British interest in germanium started in 1933 when V. M. Goldschmidt reported that some coals from the Yard Seam of Northumberland and Durham contained 30 to 50 ppm of germanium.

However, in a recent survey of all the United Kingdom's major coalfields by the Fuel Research Station of the Dept. of Scientific and Industrial Research, it was found that Goldschmidt's estimate was rather high. Ten samples of coal taken from the seam he investigated showed germanium content of 2 to 22 ppm with an average content of about 7 ppm. It appears that germanium occurs in all the major coalfields and is not localized in a few seams.

The germanium may be associated with carbonaceous material in the coal rather than with another mineral. It is believed that this is partly the reason that germanium is likely to be found in the flues of producer plants rather than in flues from ovens where coal is initially carbonized. Dry coal ash produced from dirty coals has shown an average germanium content of 0.006 pct, while clean coal ash averaged about 0.013 pct.

About 12 times the amount of germanium will be found in flue dust in comparison to ash. The amount of germanium produced from dirty and clean coals should be 0.072 pct and 0.156 pct respectively on the average. The difference between flue dust and ash may be even greater because deposits of flue dusts have been found to contain up to 2 pct germanium.

Generally, it has been found that germanium content of dust in the CO_2 flue and in the waste heat boiler area is greater than germanium content of dust from the CO flue. However, flue dust at the South Metropolitan Gas Co. plant was found to have a higher germanium content than that from around the waste heat boiler. Majority of Britain's large gas works have been surveyed for germanium bearing flue dust and are contributing their outputs to the nation's supply of germanium metal.

Johnson Mathey & Co. Ltd. considered a number of processes before deciding to investigate a metallurgical method. The firm hopes to attain an output of about 350 kg annually using flue dust from producer plants as raw material.

The initial step in germanium extraction from flue dust is smelting the dust with known collectors. Iron, nickel, and copper are suitable collectors for germanium, while copper is used for gallium collection. Flue dust is smelted with soda and lime as fluxes for the silica and alumina and with copper oxide and carbon to provide copper for the collection of the germanium and gallium. The copper-iron regulus obtained contains more than 90 pct of the germanium and 80 pct of the gallium.

Dusts high in sulphate were given a preliminary roasting to reduce sulphur content to 5 pct. This avoided the excessive formation of matte, which by taking up the copper, reduced the amount of gallium extracted into the regulus. The regulus contains about 3 to 4 pct germanium, and usually 90 to 95 pct of the available germanium is extracted. Most of the lost germanium is deposited in the flue of the furnace being used. The flue is regularly cleaned and the dust returned for processing.

To recover rare elements from the regulus, it is first converted into a solution of trichlorides. All the germanium, with some of the arsenic is recovered from the solution by distillation. Most economical method is to treat the regulus with a current of chlorine under a dilute solution of ferric chloride, which acts as a catalyst. Because the process is highly exothermic and could be applied cold without use of external heat, the rate of reaction is controlled by the rate chlorine is added to the system.

The resulting chloride solution was siphoned or blown into a battery of Pyrex stills heated by electric mantles. Vapors pass through standard Pyrex containers and the condensates flowed through a common pipeline to a Pyrex receiver. This was also connected through an empty carboy serving as a trap to a water-filled carboy collecting and hydrolizing noncondensed vapors of arsenic and germanium chlorides.

Distillation is started by slowly dropping sufficient concentrated sulphuric acid into the boiling solution to liberate enough hydrochloric acid to render the solution in the still about 7N with respect to the acid. Distillation is continued until about 25 pct of the still content is evaporated. Under these conditions the acidity of the condensate is such that it is separated into two layers. The lower layer consists of germanium tetrachloride containing up to 20 pct of arsenic trichloride and the upper layer consists of constantly boiling hydrochloric acid containing arsenic trichloride almost free of germanium.

The crude germanium tetrachloride, with a boiling point of 84°C, is separated from arsenic trichloride by careful fractional distillation. Prolonged refluxing of the liquid through a column packed with clean copper turnings is the most satisfactory way of eliminating the residual arsenic.

After refluxing for 12 to 15 hr, pure germanium containing less than 1 part arsenic in 10^7 germanium was obtained. The chloride was hydrolized to dioxide and washed free from hydrochloric acid and dried at 150°C. To produce germanium metal the oxide is placed in a pure graphite boat and heated in a tube furnace in hydrogen to about 650°C. At 650°C the hydrogen is replaced with pure nitrogen and temperature raised to 1000°C to melt the previously formed powder into an ingot. An ingot molded in a hydrogen atmosphere becomes porous on cooling because molten germanium absorbs hydrogen liberated during solidification, producing minute blowholes.

This is an abstract of an article on Production and Uses of Germanium by J. A. Gay, that appeared in the June 1953 issue of *Chemical & Process Engineering*, published by Leonard Hill Ltd., London.

BARVUE MILLING PLANT

Sets Sights For Greater Output

A little more than a year and a half ago construction started on Canada's largest initial milling plant. Today the zinc concentrating plant 7 miles north of Barraute sits on ground that once was forest and clay flats. The plant is part of Barvue Mines Ltd. zinc-silver operation. Employees of the plant live in the model community of Barvue, built like the plant in record time.

About 5000 tons of ore are handled by the plant daily, with an output of 200 tons of zinc concentrate. Management hopes to raise capacity of the $8 million plant to 6000 tons.

W. W. Weber, Quebec Department of Mines, discovered the 18 million ton sphalerite orebody in September 1950. Diamond drilling disclosed an orebody at least 2500 ft long by 100 ft wide with only 15 to 18 ft of clay overburden. Assays showed an average of 3.3 pct zinc and 1.2 ounces of silver per ton, with about 5 pct or 6 pct pyrite. Mining is by open pit. Hydraulicing removed the overburden at a cost of only about 35¢ per yard against an estimated $2.25 per yard using truck and shovel. Sufficient overburden had been removed by October 1952 to permit processing ore through the Barvue plant. About 100,000 tons of ore are loosened with each blasting and drilling cycle.

Ore is loaded in 22-ton Euclid trucks by 2½-yd shovels. The primary crusher presents an unusual design. Roof is at ground level with various crushing plant units sunk into solid rock to a depth of 60 or 70 ft.

Barvue milling plant is on the left and maintenance structures are on the right. Enclosed stockpile is in center background.

A 48x96-in. feeder and grizzly with 3-in. settings receives raw material. Oversize from the grizzly goes to a 48x60-in. jaw crusher. Crusher product and tailings from the grizzly are taken by a 42-in. wide conveyor belt enclosed in a 10-ft. diam steel tube to an enclosed stockpile located aboveground.

The stockpile has a capacity of about 8000 tons. From here two 48x72-in. feeders deposit the ore on another steel tube-enclosed conveyor which transports material to the secondary crusher house.

Ore then passes over a 48x96-in. grizzly with 1½ in. setting to a 7-ft standard cone crusher. Undersize from the grizzly and product from the 7-ft crusher are conveyed to screens in closed circuit with two 5½-ft short head cone crushers. Undersize from these screens, ½x4-in. slot, again passes through a tube-enclosed conveyor to the top level of the main milling plant.

A traveling tripper on a track running almost the entire length of the building feeds the −½ in. ore into a long catenary ore bin with an 800 ton capacity.

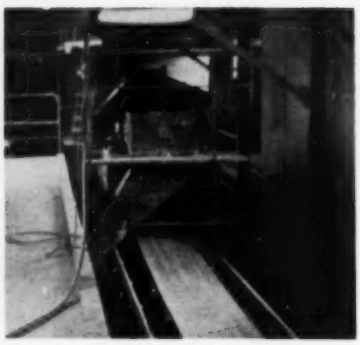
The Barvue pit is expected to produce marketable ore for some time to come. However, underground operation is planned for the future. Drilling indicates at least a 15 year potential.

About 100,000 tons of ore is loosened each drilling and blasting cycle at the Barvue mine. The drill is a Quarrymaster. Ore is further broken in the pit before starting to the crusher.

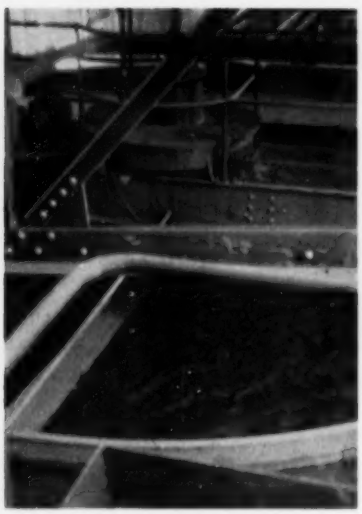
Four Mills Help Produce 200 Tons of Concentrates Per Day

Twenty-two ton Euclid trucks carry ore to the primary crusher, which is located underground.

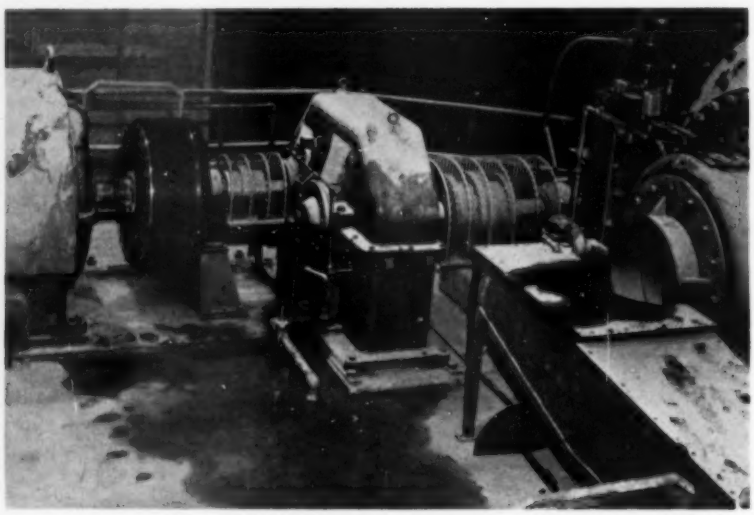
Steel tube-enclosed conveyor belts draw material to the cone crushers in the secondary crusher house.



This traveling tripper feeds a long catenary ore bin above the four Hardinge Tricone mills with —½ in. ore.

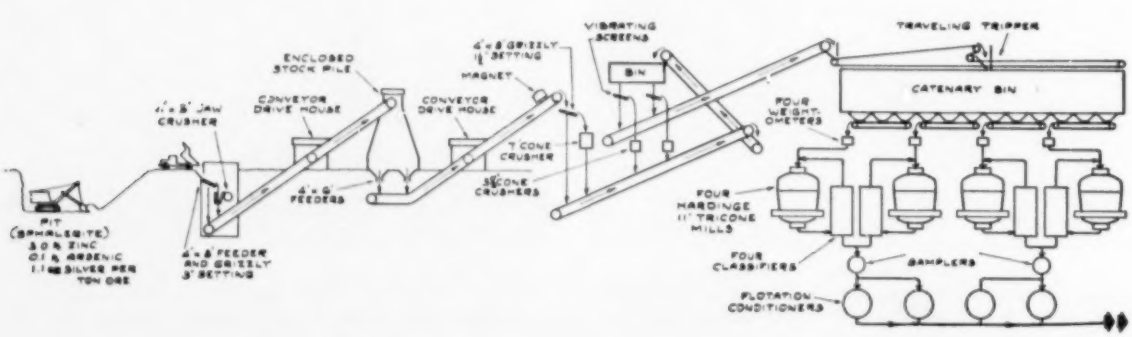


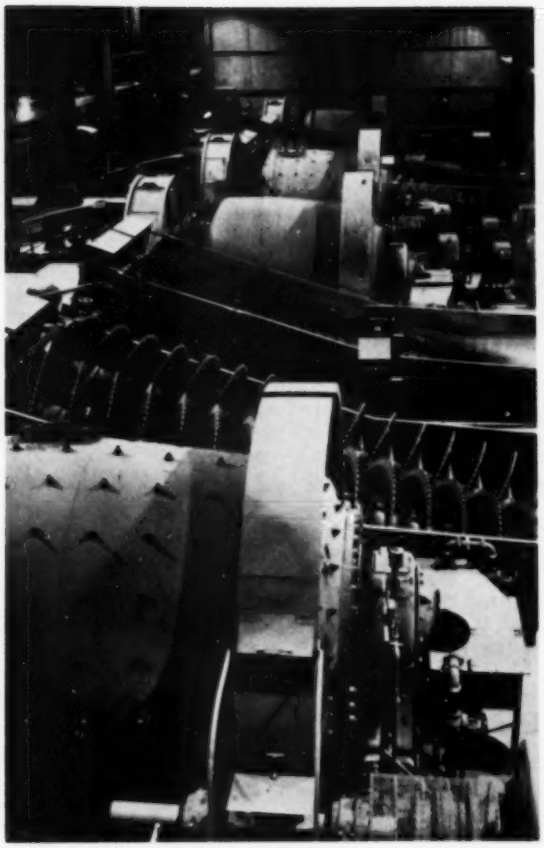
Upper unit of the 35 ft Hardinge superposed two-compartment thickener in action at Barvue.



Tricone mills are driven by 600-hp squirrel cage induction motors through a fluid drive, which allows for a 10 pct variation in speed. The fluid drive turns a gear reduction unit, cutting rpm from 1180 to 213.

The bin has 24 draw-off points feeding four belt conveyors, each followed by a Weightometer. Each belt feeds one of the four Hardinge Tricone ball mills which operate in closed circuit with 66-in. spiral classifiers. The four units are in parallel and can operate independently. Each mill is driven by a 600 hp squirrel cage induction motor through a fluid drive, turning a gear reduction unit.





Barvue management feels that 6000 tons of concentrates per day are possible with all four Tricone mills in operation. Production is currently 5000 tons per day.

Cone crusher plant is in the right background while main milling plant is on the left. View is from the crusher house toward the enclosed storage bin.

While original plans were for two-stage grinding, tests showed that single-stage grinding with a middling regrind was just as effective on the medium soft ore. Each of the Tricones is currently handling 1300 tons per day, 100 tons more than expected. With $-\frac{1}{2}$ in. feed these low speed mills produce a classifier overflow product of 60 pct -200 mesh. Ball consumption has been low and power requirements per mill have been small. Mills have water-lubricated Micarta bearings which reduce over-all power requirements an estimated 5 pct.

Tricone ball load may be increased with accompanying increase in mill capacity. Output could also be increased by running mills at higher speeds, but would entail loss of efficiency. The -200 mesh overflow from the classifiers is sampled by two automatic samplers and passed to four conditioning tanks in parallel, where flotation reagents are added, and then to the flotation cells.

Several years of economic open pit mining remain for Barvue, with operation possible to 300-ft. depth. Underground mining is planned to start well within the life span of the open pit. Fifteen years potential mining is indicated by exploratory drilling.

Preliminary Operating Data on Ball Mills, January 1953

Feed—$\frac{1}{2}$x$\frac{1}{4}$ in. slot screen undersize.
Classifier Overflow—

Screen Analysis, Pct

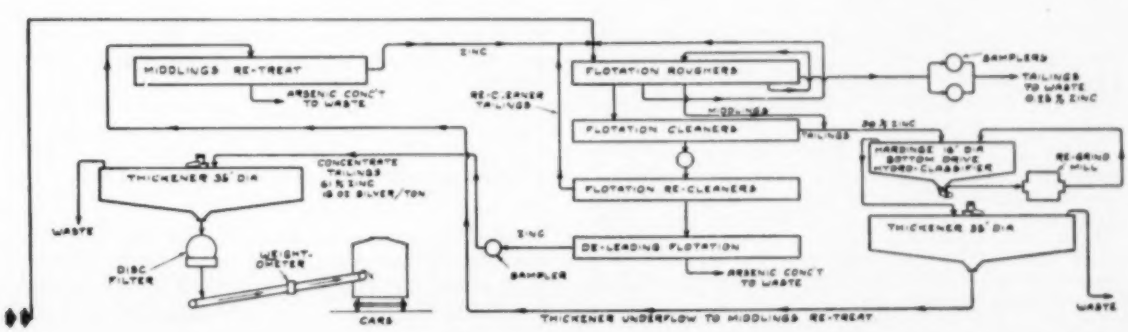
No. 2 unit at 1400 tons per day (when feed is closely controlled).

+48	+65	+100	+150	+200	−200
4.1	6.5	11.7	11.7	6.0	60.0

No. 3 unit at 1300 tons per day

+48	+65	+100	+150	+200	−200
4.7	6.9	11.2	10.6	5.4	61.2

Mill Speed—14.7 rpm, approximately 60 pct of critical, inside lining.
HP motor—600; hp required—475; through hydraulic coupling and reducer.
Ball Size (Make-up)—3½ in. cast iron.
Ball Consumption—1.2 to 1.3 lb per ton.
Lining—Wave Type, Ni-Hard.
Lining Consumption—Unavailable.
Classifier Overflow—45 to 47 pct solids.
Circulating Load—Unavailable.



Strategic Beryllium From Domestic Pegmatites

by B. H. Clemmons and James S. Browning

BERYLLIUM, obtained mainly from the beryllium-aluminum silicate, beryl, is one of our most strategic and critical metals. Strategic because suitable substitutes for many of its alloys have never been developed. Strategic because of certain uses and potential uses of a classified nature in our nuclear energy program. In this field, substitutes have been developed, but only at the expense of a reduction in efficiency.

In view of these important uses, and particularly because our domestic production of beryllium ore is very limited, the metal is a very prominent member of our list of critical materials. Dependence upon foreign countries for beryllium is illustrated by the fact that in the period 1935-1950 the United States imported 66 pct of the entire world output of the source mineral, beryl, while contributing only 7.1 pct of the world output. Essentially all metal produced is consumed in this country.

Minimum requirements of the nation for beryllium are quite small, although additional quantities could be used if available. U. S. consumption of beryl in 1936 was only 200 tons, but the trend has been upward, and 3007 tons were consumed in 1950. These quantities are small; but owing to the irreplaceable nature of the element, there must be concern about domestic supplies of the source mineral because emergency or wartime requirements, when foreign ore is obtained only with difficulty, are essentially double those of comparable peacetime years.

Even though the present market value of beryl ranges from $400 to $500 per ton, known tonnages of domestic ore that can be economically mined and beneficiated are small. Large increases in these tonnages are unlikely, although a search for additional reserves is under way.

There are relatively large tonnages of low-grade ores, which usually contain less than 1 pct beryl, and field work probably will develop additional reserves of this nature. Unfortunately, few of these ores can be economically beneficiated unless some accessory mineral is concurrently recovered to defray a major part of over-all costs.

Various investigators have devised flotation methods for recovering beryl from feldspar-mica-quartz pegmatites. Undoubtedly, coordinated processes will be applied to certain of these ores; however, limited reserves and uncertain markets for feldspar and mica probably will preclude any large production of beryl from ores of this type.

A much more promising potential source of domestic beryl appears to lie in the spodumene-bearing pegmatites of the Lincolnton-Kings Mountain area of North Carolina.

There exists a strong and enlarging market for lithium salts, largely obtained from spodumene. Large reserves of this mineral occur in the North Carolina district, and mining and milling operations may ultimately provide for the treatment of 2000 or more tons of ore per day. These deposits contain as an accessory mineral 0.3 to 1.5 pct beryl—usually in crystals smaller than ¼-in. size. Recovery of beryl on this basis could at least triple present domestic production.

Under DMPA sponsorship the Bureau of Mines at Tuscaloosa, Ala., is studying the possibility of recovering beryl from these spodumene pegmatites. The Foote Mineral Co., which is operating a spodumene-recovery plant at Kings Mountain, N. C., is cooperating in the work.

Beryllium is a consituent of about 30 minerals, but its only commercial source at this time is beryl. Beryllium minerals occur principally in pegmatites, granites or syenites, in association with feldspar, mica, spodumene, and various other minerals. Commercial production thus far has been limited largely to pegmatites.

Beryl is not present in all pegmatites. Where it does occur, the mineral is usually present either as widely disseminated grains or as local or somewhat banded enrichments, which on occasion have yielded very large crystals—in some instances weighing as much as 50 to 60 tons. Virtually all beryl thus far produced in the United States has been obtained from enrichments of this type, where the crystals were of ¾ to 1-in. or larger diameter and would yield to hand-picking or cobbing. Much of the output has been as a byproduct operation in producing feldspar or strategic mica.

Future recovery of beryl probably will depend more on fine-grain concentration methods than in the past, because known occurrences of coarse-grained mineral have been largely exhausted.

Occurrence

Beryl-producing countries during 1950 marketed the following percentages of the total world production: Brazil 39.5 pct; Union of South Africa 22.6 pct; Southern Rhodesia 12.7 pct; United States 7.6 pct;

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Madagascar 7.3 pct; Mozambique 3.9 pct; miscellaneous 6.4 pct. In the United States, beryl deposits occur in South Dakota, Colorado, and in the New England, Southern Appalachian, and Rocky Mountain areas. Production to date has come principally from the Black Hills area of South Dakota, as a coproduct with columbite-tantalite, lithium minerals, feldspar, and strategic mica. Appreciable quantities have also been produced in New England, Colorado, and New Mexico.

Reserves

Relatively little positive information is available on world beryl reserves. Brazil is believed to have the largest tonnage of beryl-bearing rock, with Argentina, United States, India, Union of South Africa, and Australia following in order of reserves.

In the United States, at the present time, it is believed that the greatest potential reserves of beryl occur in the pegmatites of the tin-spodumene belt of the Carolinas, where total ore reserves may exceed 15 or 20 million tons of material containing 0.3 to 1.5 pct beryl.

Production and Consumption

The wide commercial application of beryllium and its alloys was largely an outgrowth of World War II. In 1936 reported world production of beryl was 480 tons, which sold for $40 per ton. In 1943 world production amounted to 6000 tons, worth approximately $120 per ton. Thereafter, production decreased for a time but rose again to 7300 tons in 1950, the price advancing to $300 per ton. Appreciable quantities of the beryl were stockpiled during the high production years, as the highest consumption figures reported for beryl have been 3058 tons in 1943 and 3007 tons in 1950.

Highest domestic production of beryl recorded was 559 tons in 1950, when a limited deposit of pure beryl was discovered and mined. In some years domestic production has been as little as 40 tons.

Uses

A preponderant part of the beryllium consumed at this time is used as a hardening agent for various alloys—especially those of copper.

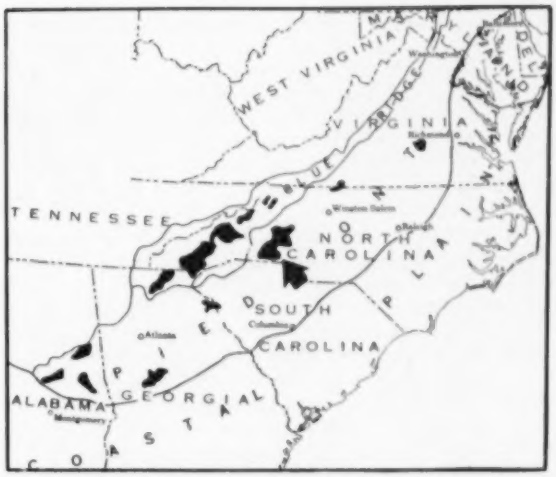
Beryllium-copper alloys have commercial and strategic importance because of their resistance to fatigue, corrosion, heat, and wear. Their hardness, tensile strength, high electrical and thermal conductivity, low creep tendency, and low sparking and nonmagnetic properties are other desirable attributes. They are widely used in various aircraft parts. Other beryllium uses are for dental and surgical alloys, diamond-drill-bit matrix metal, watch balance wheels, and current carrying springs.

In the atomic energy field, beryllium has a number of important uses, most of which are classified.

Principal Beryllium Minerals

Mineral	Simplified Formula	Theoretical Pct BeO
Beryl	$Be_3Al_2(SiO_3)_6$	13.97
Phenakite	Be_2SiO_4	45.45
Chrysoberyl	$BeAl_2O_4$	19.71
Helvite	$R_4Be_3Si_3O_{12}S$	12.58 to 13.52
Gadolinite	$Be_2FeY_2Si_2O_{10}$	10.69
Beryllonite	$NaBePO_4$	19.69

Mineral group, comprising three members: Helvite, (Mn_4); Danalite, (Fe_4); Genthelvite, (Zn_4).



Outline map shows principal pegmatite areas of the Piedmont and Blue Ridge regions. (After U.S.G.S.) Bold arrow indicates Kings Mountain, N. C., pegmatite deposit.

Beryllium oxide is used as a high temperature refractory for aircraft sparkplugs and ultra-high-frequency insulators; in rocket combustion chambers, and in high-temperature furnaces. The oxide also has application in the nuclear energy field, in ceramic glazes, and in special glasses.

Current market quotations for beryl ore are $46 to $48 per unit of contained beryllium oxide when the ore or concentrate assays 10 to 12 pct BeO. Beryllium metal is quoted at $95 to $105 per lb, depending on purity and form. Beryllium-copper master alloy is quoted at $40 per lb of contained Be plus 29.3¢ per lb of contained copper.

To stimulate production by small producers, the General Services Administration in October 1952 announced a purchase program whereby purchase depots at Spruce Pine, N. C., Custer, S. Dak., and Franklin, N. H., could accept up to 25 tons per year of beryl from individual producers at prices of $40 per unit for 8.0 to 8.9 pct beryllium oxide products; $45 per unit for 9.0 to 9.9 pct products, and $50 per unit for products containing over 10 pct beryllium oxide.

Processing

Beryllium has been described as the "world's No. 1 metallurgical headache" because of various difficulties encountered in recovering and working the metal. Beryllium minerals usually occur in forms that have only limited or poor response to normal concentration methods; in many instances they occur in association with minerals that can be rejected only with extreme difficulty. Pure beryl still contains only 4 to 5 pct beryllium metal, or 12 to 14 pct beryllium oxide. The most practical methods available for recovery of the metal from the source minerals are, by most standards, unusually complicated and expensive. Finally, although there are several methods of analysis for beryllium or beryllium oxide, none can be classed as simple or fully satisfactory.

There is a possibility that some heavy-media process can be applied to beryl ores to obtain a partial concentration. However, very close control will be necessary, because the 2.7-2.8 specific gravity of beryl is little different from that of feldspar, quartz, mica, and spodumene. This lack of specific gravity differential largely precludes use of jigs, tables, or similar gravity-type concentrating devices.

Gaudin and associates, in the April 1950 MINING ENGINEERING, proposed a process for treating ¾-in. to 1-g particles of beryl with a "kicker" that responded to the neutrons emitted by beryl after being irradiated in gamma rays. A device of this type may find application but appears to be too complicated and expensive for the average small producer. Under some conditions beryl can be separated by electrostatic separation.

Beryl can be recovered from ±⅛-in. to 48-mesh sizes by agglomerate tabling. But, the 48-mesh material would still require treatment by flotation. Hence, for simplicity, it is probable that flotation alone will be the most promising method of recovering beryl in sizes too small for hand-picking.

Technologists of the Bureau of Mines at College Park, Md., Salt Lake City, Utah, and Rolla, Mo., have published reports of results of flotation research on beryllium-bearing ores for their areas. Separations were of the same general type. After vigorous surface conditioning, usually followed by water washing, beryl was floated by an anionic collector of the fatty acid type.

S. M. Runke of the Rapid City, S. Dak., station of the Bureau of Mines recently reported a new type of separation which eliminates the expensive preflotation conditioning. Bulk flotation of feldspar and beryl is followed by retardation of feldspar and beryl flotation by petroleum sulfonate-type collectors.

In all of these flotation separations quartz and feldspar can be rejected from beryl without undue difficulty. Mica tends to report in part with the beryl and may be removed by cation active reagents at some point in the process.

Separation of beryl and spodumene is a much more difficult problem because the flotative response of the two minerals under most conditions is essentially the same.

At Tuscaloosa, in work on the Kings Mountain spodumene pegmatites, the Bureau has recently developed a reagent combination that retards beryl while permitting spodumene to float. Various details remain to be worked out, but there is reason to believe that the new procedure may permit commercial separation of beryl and spodumene by flotation. The nature of the separation cannot be revealed at this time, but a report on the work will be published at the earliest practicable date. To provide some idea of the progress, from ore containing 0.3 pct beryl products have been obtained containing 18.0 pct beryl—about 60:1 ratio of concentration.

Conclusion

Technology now places a great deal of dependence upon the beryllium alloys that have been developed for various special-purpose applications, and an appreciable hardship would be suffered by the nation if these alloys were suddenly unavailable.

When all aspects of the problem are considered, it is readily apparent that present unstable world conditions dictate that the nation *must* make a concerted effort toward attainment of a greater self-sufficiency in its production of beryl. It is improbable that our requirements can be completely satisfied, but there is reason to believe that present production can be appreciably increased.

The most promising source of increased U.S. beryl production is the spodumene-bearing pegmatites of the Carolinas. Recent test work promises to solve the problem of concentrating the small percentages of beryl contained in these deposits.

Moisture Protection for Electrical Equipment

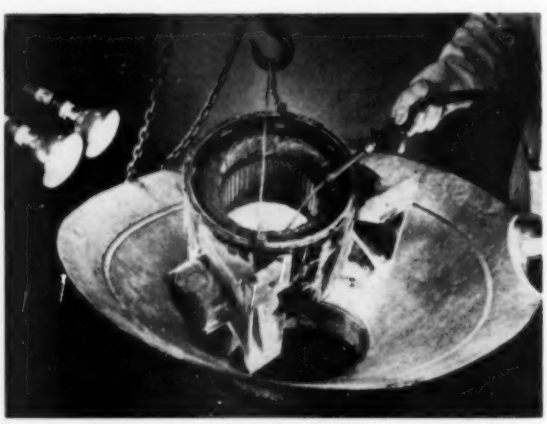
When the Tecolote Tunnel project in Southern California hit 2000 gpm of warm and acid water, 27 motor armatures burned out in two months, fuse terminals corroded in a week, and switches failed. Electricians finally tested Safe-T-Seal, a protective material already being used in food packing and chemical industry plants having moisture and corrosion problems. First success extended motor life from days to months and led to treatment of all exposed electrical equipment. According to Halvorson Contractors' chief electrician Safe-T-Seal licked the electrical maintenance end of the Tecolote job.

Widely used in fish packing, dairy product, and chemical plants, first mining industry users reported are Florida phosphate plants, a coal mine, a cement plant, and a dredge destined for tropic service in Indonesia.

Not a paint, Safe-T-Seal does its job by impregnation and adsorption, rather than by building a surface film. Action is described by manufacturer as chemically impeding ionization and fortifying insulation to neutralize contact of atmospheric conductive paths. Motor and equipment life under difficult conditions is stated to be extended by reducing deterioration of insulation due to presence of moisture and oxygen.

Application is simple, and said to be suitable for all types and sizes of equipment. Material is not inflammable nor toxic, and has consistency of water at 160°F treatment temperature. Estimated cost for material labor to treat motors of less than 50 hp is about $1 per hp—with cost per horsepower decreasing for bigger motors.

Typical applications so far, exposed motors on towers, on dredges, in crushing plants, and in wet, acid, inside locations, suggest this material may find wide mining industry use in underground operations, in beneficiation plants and in refineries.



Motor armature for Tecolote Tunnel project being treated with Safe-T-Seal to resist moisture and corrosion. Dispenser recirculates heated fluid, and heat from infra red lamps aids in draining excess fluid back to tank.

Mining and Concentration of Ilmenite And Associated Minerals at Trail Ridge, Fla.

by J. H. Carpenter, J. C. Detweiler, J. L. Gillson, E. C. Weichel, Jr., and J. P. Wood

ILMENITE, rutile, zircon, and other heavy minerals are found in small amounts in the sand that covers most of Florida. Small enriched deposits occur on the beaches and coastal dunes. One beach deposit east of Jacksonville was worked during World War I and another near Vero Beach during World War II. Both ceased operation when the resumption of imports reduced prices.

Early in World War II reduction of rutile imports made a domestic source of the mineral necessary to maintain the expansion of armaments. Explorations made near Jacksonville discovered a relatively large body of low-grade ore about 10 miles inland from the beaches. A plant installed by Rutile Mining Co. of Florida using both flotation and tables encountered difficulties because of low plant capacity and organic slimes in the ore. In 1944 Humphreys Gold Corp. solved the problem of concentrating the low-grade ore by using the newly developed Humphreys spiral concentrator and by mining with a hydraulic dredge. This combination of low cost mining and concentration permitted the plant to continue operation in competition with foreign ores when imports were resumed following the war.

The success of the Jacksonville operation renewed interest in Florida as a source of titanium. An extensive survey of the state was made by E. I. du Pont de Nemours and Co., Inc., under the direction of J. L. Gillson in 1945 to 1946. Sampling was carried on by drive pipe drilling to depths of 20 to 25 ft. Encouraging values were discovered near the location of the present Trail Ridge mine, 50 miles southwest of Jacksonville, near the town of Starke.

The United States Bureau of Mines was interested in exploring for heavy minerals in Florida, and on the recommendation of both the state geologist of Florida and of Du Pont geologists, drilled deeper where marginal indications were found on Trail Ridge. In 1947 it was discovered that sufficiently higher values occurred at depth to make the deposit commercial.

The orebody at Trail Ridge is a long sand deposit averaging about 1 mile in width and 35 ft in depth. It is approximately 1½ miles wide at the north end of the portion now being worked, tapering to a blunt point 3 miles to the south. The ore reaches a maximum depth of 65 ft near the center and feathers out into barren sand at the edges. The ground surface is relatively flat and is covered with vegetation including pine, scrub oak, palmetto, and occasionally in swampy areas, cypress.

The remain of a dense woody growth underlies and marks the bottom of the ore zone. It is difficult to drill through this layer, but in some cases where it is less than 5 ft thick it has been possible to drive through the wood. Sand lying below is coarser than that in the ore zone and contains no values.

The wood layer consists of unconsolidated carbonized fragments of branches and other forest trash associated with a considerable amount of ar-

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The Transactions papers appearing in Mining Engineering during 1953 will subsequently appear in AIME Transactions Vol. 196, and may be permanently referenced to that volume.

gillaceous material. Fragments of branches up to 2 in. diam and pine cones have been recovered.

All of the sand in the area is mixed with varying amounts of partially carbonized organic material that contains 70 pct volatile matter and has a clay-like ash. The quantity and consistency of the organic matter varies from a small amount of brown dust at the surface to a black, tar-like material sufficient to cement the sand below the water table into a formation known locally as *hardpan*. The cemented sand occurs in layers and lenses varying in thickness from a few inches to 40 ft with no horizontal continuity. Its hardness is variable, at times resembling soft sandstone.

Values begin at the surface. There are local horizontal and vertical variations in grade, but as a whole 4 pct of the ore is made up of minerals having a sp gr greater than 2.9. Forty-five percent of these are titaniferous. The major associated minerals are zircon, staurolite, kyanite, sillimanite, and tourmaline. Andalusite, pyroxene, spinel, corundum, and monazite occur as very minor constituents.

The principal mineral of the titaniferous group is ilmenite, or more properly its ferric iron analogue similar in composition to arizonite, which analyzes about 63 pct TiO_2. The balance of the group is a non-magnetic fraction containing altered ilmenite, leucoxene, and a small amount of rutile. The sand as a whole contains about 1.8 pct titanium mineral.

J. L. Gillson[1] has described elsewhere the occurrences and steps in geological history which are common to all commercial deposits of titaniferous sand. These steps are:

1—The existence of a *hinterland* of crystaline rocks in which ilmenite and rutile were accessory minerals, as in the case of the Trail Ridge deposit, Southern Appalachia.

2—A period in which a deep soil zone formed, from which all magnetite and all soluble silicate minerals were leached by organic acids, leaving the quartz, titaniferous minerals, and insoluble silicates behind.

3—An uplift followed by rapid erosion of the soil zone and the dumping of the sands into the ocean, and a later uplift raising the sands to form a source of heavy minerals that again washed into coastal waters.

4—Transportation by ocean currents of the redeposited sand along the bottom of the sea and the building of offshore bars. In some locations the bars became attached to the shore to form a spit. As these bars or spits grew in height, breakers formed and the force of the waves carried the sand into deep water on the landward side, leaving the heavy minerals behind. Thus a sand deposit was built carrying a modest enrichment of heavy mineral. In India and Brazil slow emergence of low-grade zones and further wave action formed very rich beach deposits. In Florida the elevation was apparently so rapid that there was not time for further concentration of any extent to take place.

Cooke[2] has shown that during the Sunderland Stage of the Pleistocene Period a small spit was extended from Southern Georgia to the middle of what is now Florida. Sea level at that time was some 200 ft higher than now. It was during the period of this spit formation that local concentration of minerals took place and an orebody was formed.

Later, when the spit emerged, it became the backbone of peninsular Florida and is now called Trail Ridge. Discovery of an area in which the titanium minerals were concentrated in sufficient amounts to be recovered by modern mining and milling methods led to the development of the Trail Ridge mine.

Drilling: The sandy nature of the ore and the fact that the water level was very near the surface precluded the use of ordinary drilling methods to prospect and develop the deposit. Development of a modified core drill by the cooperative efforts of the Bureau of Mines, Du Pont, and Humphreys greatly facilitated the exploration and proving of the Trail Ridge orebody. With this type of drill, the core is continuously removed by a flow of water within the drill casing. The drilling assembly consists of a 200-lb hammer, an elongated hollow drive head with a hose connection in the side, 10-ft lengths of ¾-in. jet pipe, and 1½-in. diamond drilling casing. The first length of jet pipe passes through and is welded to the hammer. The end of the pipe above the hammer is connected by a hose to a pump. Its length below the hammer is such that it extends through the drive head to within 6 in. of the bottom of the first section of casing. Consequently, as equal lengths of jet pipe and casing are added, the relative position of the lower ends of the two pipes is always the same. As the casing is driven, water pumped through the jet pipe breaks up the rising core of sand in the casing and carries it to the drive head where it discharges through the side opening and flows through a hose to the sample tub. Holes 75 ft deep are frequently drilled.

Samples are obtained from each 5-ft section of ore. Drilling is continued until some formation such as clay or wood layer is reached, or when panning of the samples indicates that the bottom of the ore has been passed. A 3-man crew averages about 200 ft of hole per day. In the early development, drill spacing was on 330x660-ft. lines; for operational purposes holes are spaced on 100-ft. centers. The equipment, mounted on a 6x6 truck, includes a folding 25-ft mast, a walking beam, a hoist, a water pump, a gasoline engine, and a 250-gal water tank.

The development drilling by Du Pont indicated that there was a sufficient reserve on the land held by the company to justify the erection of a plant to treat 20,000 long tons of ore per day for the production of 100,000 long tons of titanium mineral a year. In January 1948 Du Pont engaged Humphreys to design, construct, and operate a plant to exploit this reserve.

Dredging was considered the most economical means of mining this type of deposit. The next consideration was the location of the concentrator in relation to the dredge. Alternate plans were proposed: 1—to bring the ore to the mill and 2—to bring the mill to the ore.

The first proposal, to locate a mill centrally on land, required pumping approximately 1100 long tons of sand per hr and 18,000 gal of water per min an average distance of over a mile. The high ratio of concentration and the necessity of backfilling the mined area would require pumping nearly an equal amount of tailing and water the same distance.

According to the second plan, a plant floating on the dredge pond could follow the mining. It would then be necessary to pump the large amounts of feed and tailing less than 1000 ft. Pumping requirements for any considerable distance would be reduced to approximately 40 tons of concentrate per hr with 500 gal of water per min.

The second proposal was adopted and the plant was designed and built. Construction was started in

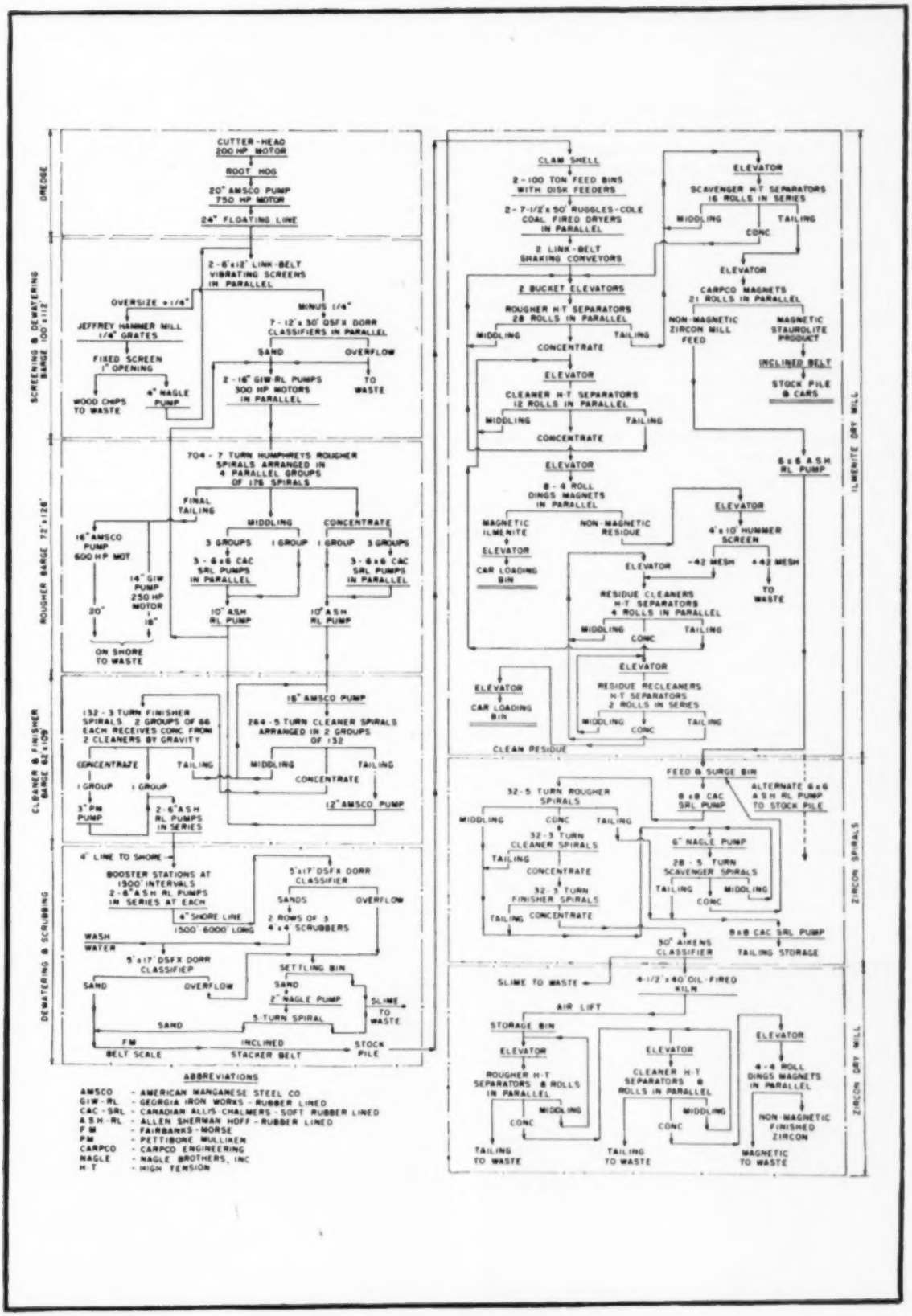


Fig. 1—Humphreys Gold Corp. Trail Ridge plant flowsheet, Feb 1, 1953.

April 1948 and completed in a year. Hulls for the dredge and concentrator were assembled in dry pits which were later flooded, and the equipment was installed on the floating units. The frontispiece, an aerial view of the plant, shows the dredge and wet mill in the pond at upper right, the acid treatment settling area to the left, and the dry mill, zircon mill, offices, and shops in the center foreground.

The dredge hull was fabricated from plates cut and welded on the site. The three barges carrying the concentrator were assembled from navy pontoons designed for construction of temporary docks and barges.

Floating Concentrator: The plant is unique in its compactness, simplicity of flowsheet, see Fig. 1, and mobility. Three barges with total displacement of 3000 tons and total deck area of 27,000 sq ft carry all the equipment necessary to process 20,000 tons of feed per day. Separate barges were used to provide a space of suitable size and shape for each group of equipment.

One barge, 100x112 ft, carries two 6x12-ft vibrating screens, an oversize crusher, seven 12x30-ft dewatering classifiers, and the spiral feed pumps and bins, see Fig. 2. The 72x126-ft rougher spiral barge, Fig. 3, supports 704 spirals, product transfer pumps, the main tailing bin, and tailing pumps. The 62x109-ft cleaner barge, Fig. 4, carries spirals used in the cleaner and re-cleaner circuits, the cleaner feed bins, and pumps for feed, tailing, and concentrate. The plant uses a total of 30 pumps, ranging in size from 3 to 16 in.

The barges are tied together by flexible connections, which allow for vertical movement as the load varies on each section and permit the plant to be moved as a unit. Interbarge pipelines are connected with dredge sleeves and hose.

Power totaling 1500 kw at 2300 v is carried to the barges on 3-conductor cables. Feed from the dredge reaches the barges through a pipeline floated on pontoons. Tailing pumps are connected through dredge sleeves to shore lines which transport tailings to the area being backfilled.

The plant is normally tied to the bank of the dredge pond, but at times it is moored in open water and held by cables attached to deadmen on shore. At the present mining rate the plant is moved about every four weeks. Movement of the plant requires approximately 12 hr including rearrangement of shore pipelines and power cables.

Operations

Clearing: As there is no overburden to be removed, it is necessary to give considerable attention to the removal of surface vegetation to prevent fouling of the dredge cutterhead and pump.

After standing timber is removed, stumps are pulled with a stumper and large roots are picked up with a root rake mounted on the front of crawler tractors. A rooter and a tandem disc, which are pulled by a tractor, unearth and reduce the smaller roots to short lengths that will pass through the dredge pump. Trash, stumps, and roots are gathered and burned.

This clearing operation removes the majority of the roots. Those remaining, combined with fragments of stumps which occur 5 to 10 ft below the surface, originally gave trouble in the dredge pump. The problem was solved by installation of a plant-developed *root hog* and *wiper blade* described below.

Blasting: The presence of hardpan and the poor flow characteristics of the sand make it necessary to blast ahead of the dredge. Blast holes are drilled in rows about 20 ft apart and parallel to the face of the dredge pond. The drill rig developed at the plant has a drill mounted on each end of a half-track. This arrangement permits two holes to be drilled simultaneously at 28-ft intervals in the rows. Each end of the blast drill rig is equipped with a 45-ft mast and an electrically driven capstan. A 40-ft drill pipe with a 6-in. diam bladed cutter is supported by a rope passing over the masthead pulley to the capstan. High pressure water is carried to the top of the drill pipe by a hose. No hammer or casing is used. Alternate tightening and loosening of the rope, which is wrapped around the capstan head, imparts a chopping action to the cutter blade while water is pumped into the hole.

Sand, loosened by the cutter blade and the jet of water, is flushed out and leaves an open hole of about 8-in. diam extending to the bottom of the ore. Holes are loaded with DuPont Nitramon and detonated with Primacord and millesecond delays.

Dredging: The suction cutterhead dredge, Fig. 5, is capable of digging 1200 tons per hr to a depth of 45 ft below the water level. A 20-in. dredge pump powered by a 750 hp motor is used as a means of

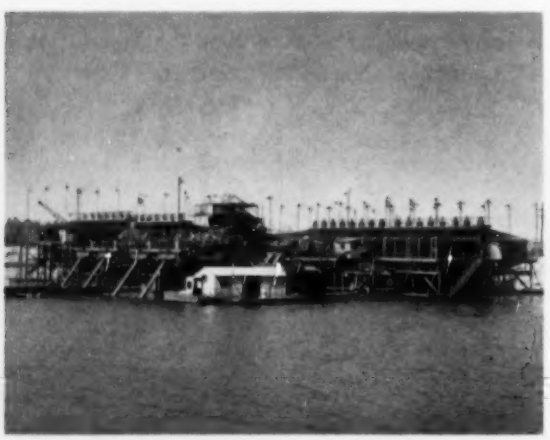


Fig. 2—Floating concentrator. Screening and dewatering equipment is in the center, the rougher spirals to the right, and finisher section to the left.

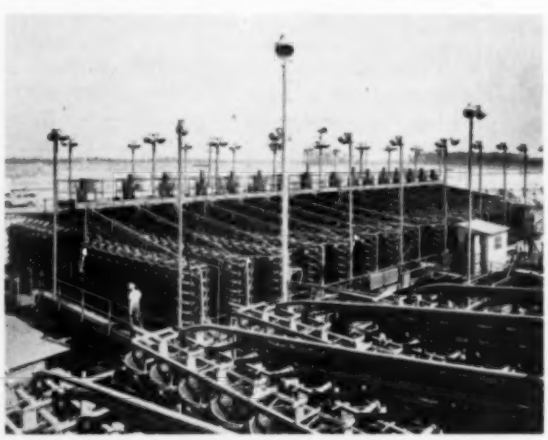


Fig. 3—A view of the 704 7-turn rougher spirals, showing the feed system. The barge which supports this equipment is 72x126 ft.

moving the ore from the ground to the wet mill. The dredge pump suction line, of 24-in. diam, is extended down the ladder and terminates inside the cutterhead. The revolving cutter loosens the sand so that it may be picked up by the pump suction.

The cutterhead is made of six curved blades assembled to form a hemisphere. The blades are shaped in such a way that when the cutterhead revolves, sand is forced toward the pump suction intake within the cutterhead. The head is attached to a 9-in. shaft driven at 16 rpm by a 200-hp motor through a gear reducer located near the top of the 65-ft ladder. Digging depth is controlled by raising and lowering the ladder.

The dredge pump discharges to a 24-in. pipeline, made up of 40-ft sections of pipe supported on pontoons, which connects with the wet mill. Connections between joints are made with rubber dredge sleeves. The flexibility of the couplings, together with the arrangement of the line in an ell shape, permits pipe to be added or taken out in sections ranging from 80 to 160 ft. The line may vary 280 to 1060 ft, depending on the dredge position.

Power totaling 800 kw at 2300 v is conducted from shore to the dredge by a 3-conductor cable supported on pontoons.

When mining, the dredge is stepped forward into the toe of the bank by the alternate use of two spuds located at the stern. Using one spud as a pivot, the dredge is swung from side to side so that the cutterhead makes a cut approximately 200 ft wide. The swinging is controlled by swing winches on the dredge which haul on lines attached to 2½-cu yd drag-line buckets acting as deadmen on shore. Drag-line buckets are used because of their tendency to pull into the ground when tension is applied to the lines. The dredge starts a mining cycle about 200 ft from the wet mill and moves forward, in successive cuts about 150 ft wide, to the full extent of the pipeline. Usually the area mined in one cycle is equivalent to 8 acres. The wet mill is then moved forward and the cycle repeated. The dredge operator is guided by markers on shore, a depth gage, and a chart showing the depth of ore at each station.

Because of lack of storage capacity at the wet mill, the dredge must produce at a uniform rate to maintain proper spiral loading. Control of the production rate is aided by vacuum and pressure gages installed at various points in the pumplines and by an ammeter on the dredge pump motor. A flow meter which integrates the flow and pulp density to dry solids weight gives the operator a continuous chart of dredging rate and total tonnage dredged.

Root Hog: Roots not recovered in clearing are waterlogged and sink to the bottom of the pond. Before the *root hog* was developed these and large chunks of hardpan picked up by the suction severely handicapped operations by plugging the pump.

The root hog is essentially a chopper contained in a box welded into the dredge pump suction line. A punch plate with 5-in holes starts at the bottom of the inlet to the box and slopes upward at 15° towards the discharge, ending in an enlarged chamber which holds the chopper.

The bulk of the material entering the root hog passes through the plate openings and to the pump. Larger pieces of roots and hardpan are carried by the force of the stream to the chopper which acts as a combination hammer mill and wood chipper. It consists of a heavy rotor with teeth that mesh between a fixed set of dies. The rotor turns at 300 rpm, crushing the oversize and roots between the dies and teeth. The reduced matter falls into the main stream and passes through the pump.

Power is applied to the rotating element by a drive outside the box. Shear pins protect the equipment from damage by tramp iron. Stuffing glands around the rotor shaft prevent loss of vacuum in the suction line.

Wiper Blade: The long thin roots that passed through the punch plate had a tendency to hang up on the leading edge of the impeller vanes of the dredge pump. The wiper blade was developed to eliminate the periodic shutdowns required to clean out the pump.

A 1½x4x5-in. steel blade is welded to the suction face plate so that it is parallel to the pump shaft and extends into the pump the full width of the vanes. Clearance between the blade and vanes is about ½ in. As the impeller rotates, small roots hanging on the vanes are sheared off and pass through the pump.

Wet Plant: The wet mill treats approximately 1100 tons of ore per hr containing 4 pct heavy mineral and produces about 45 tons of concentrate per hr, averaging 85 pct heavy mineral. This is accom-

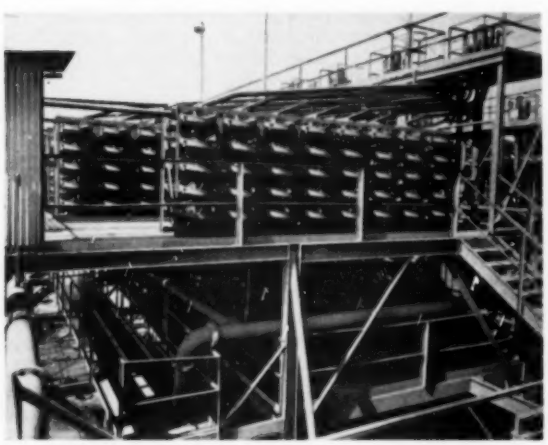
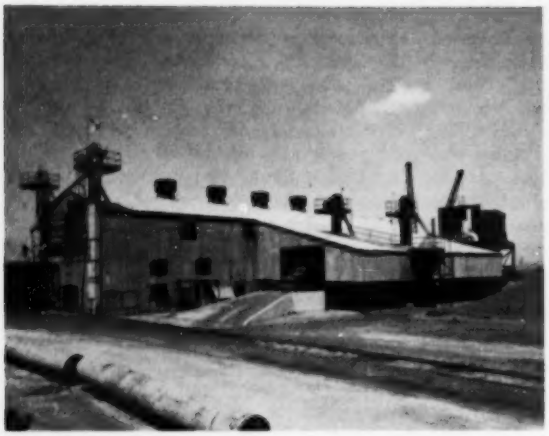


Fig. 4—A portion of the cleaner and re-cleaner section. The 5-turn cleaners are on the upper deck with the 3-turn re-cleaners below.

Fig. 5—Dredge. The 200-hp cutterhead drive is on the forward end. The spuds and the supporting frames are at the stern.



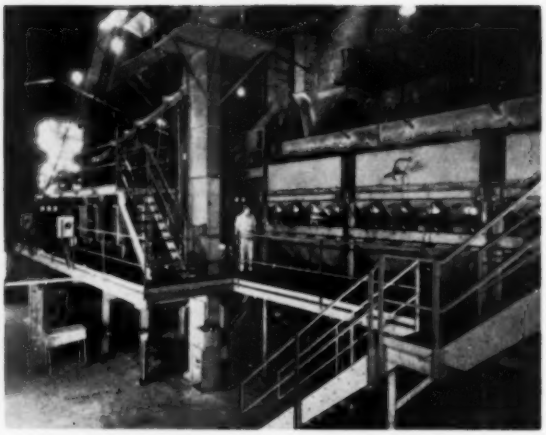


Fig. 6 (left)—Exterior view of the ilmenite dry mill. Fig. 7 (right)—Interior view of the ilmenite dry mill. At the right is a portion of the high tension separators which split the titanium minerals into silicates. At the left are the magnets which extract staurolite from the silicate fractions.

plished in three stages of spiral concentration as shown in Fig. 1. Feed from the dredge is screened at ¼ in. on vibrating screens. The oversize is conveyed to a hammer mill to reduce hardpan. Roots and wood chips in the mill discharge are removed on a fixed screen while the freed sand grains are returned to the screens. Undersize from the screens is dewatered in rake classifiers, repulped to approximately 30 pct density and pumped to the rougher spirals. This is the only preparation required for the plant feed. The product called middling in the flowsheet is low-grade concentrate which is recirculated for further concentration with no additional treatment. Each Humphreys spiral is made of cast-iron trough-shaped sections so designed that when assembled they form a helix of the required number of turns. The pulp is introduced at the top and flows by gravity down the spiral. The sand and water are carried to the outer section of the trough. The lighter sand grains and most of the water continue to flow in this section and are discharged as tailing at the bottom. The tailing flows to the main tailing sump and is pumped to the dredged area being backfilled. The heavy mineral particles settle out and migrate to the inner edge of the trough where they form a thin moving band. The mineral that has reached the band during each turn is drawn off through ports connected by hose to a two-compartment collector pipe in the center of the spiral. Concentrate withdrawn from the top turns enters the upper port of the collector pipe, and middling from the lower turns is drawn off to the lower port. The rougher spiral section contains 704 seven-turn spirals rejecting a final tailing which is pumped to spoil areas. The concentrate is retreated in 264 five-turn cleaner spirals. Tailing from this circuit is recirculated through the roughers. The cleaner concentrate is further treated on 132 three-turn spirals to produce finished concentrate and a recirculating tailing. The finished concentrate is pumped to the dry mill where it is dewatered, scrubbed to remove adhering organic slime, and stockpiled for further treatment in the dry mill.

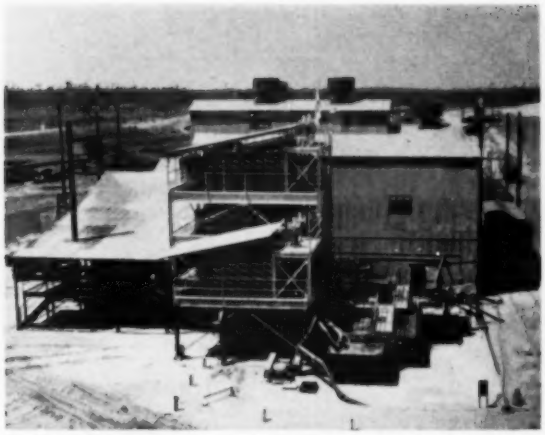
Waste Water Treatment: Pond water is used for make-up and wash water wherever possible. However, it is necessary to use fresh water for pump seals and wash water on the finisher spirals. This water, along with the accumulation from heavy rainfall, makes it necessary to waste approximately 3000 gal per min to public streams. The organic material in the orebody forms colloidal slime in the pond which has a very high coloring capacity. The discharge of this water to streams without clarification would seriously interfere with natural plant and animal life. The slime is flocculated by reducing the pH of the excess water to approximately 3.5 with sulphuric acid. The water then flows to a 20-acre settling pond left from previous mining operations where the coagulated sludge settles. The clear overflow from the pond is neutralized with lime before entering the stream. Both acid and lime are fed by automatically controlled equipment.

Maintenance: Abrasion of all iron equipment by the sand presented a major maintenance problem in the operation of the wet mill. Rubber and neoprene proved to be the answer to the problem. Approximately 7½ miles of rubber and neoprene tubing and hose, ranging in size from 1½ to 8 in. diam, have been installed as replacement for pipelines and small launders.

Tubing is supported in angle iron racks or used as liners for pipes to carry streams flowing by gravity. High pressure hose is used to replace pumplines whenever possible. The larger launders are lined with ¼-in. rubber sheet bolted in place.

All the spirals have been lined with ¼-in. sheet Neoprene at the plant by a process of dry vulcanizing. This process is also used to line launders, bins, and other equipment subject to sand abrasion. Neoprene-lined launders in service for three years show negligible wear compared to the complete failure of a similar thickness of steel within three or four months. Rubber-lined pumps have proved to be very satisfactory at this plant. Nearly all the sand pumps in use are of this type and replacement of the remaining metal pumps, except the one on the dredge, is scheduled in the near future.

Of particular interest are the newly developed 16-in. rubber-lined pumps believed to be the largest in use at this time. These pumps have a capacity of 8000 gal per min and handle approximately 14,000 tons of sand per day. One has been in use for over six months without appreciable wear.



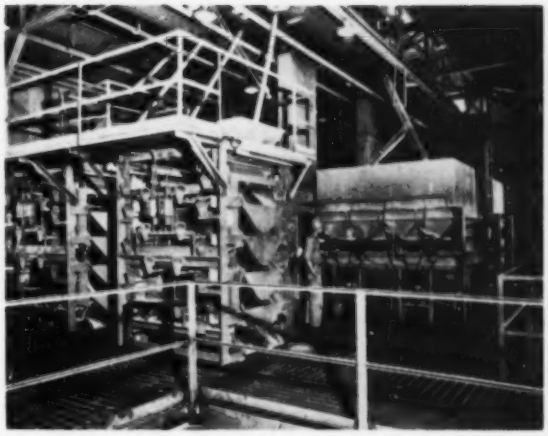


Fig. 8 (left)—Exterior view of the zircon unit. Fig. 9 (right)—Interior of the zircon unit showing high tension separators and magnets. Similar magnets are used in the ilmenite mill to separate ilmenite from the non-magnetic titanium minerals.

Dry Plant: The bulk concentrate is further treated in a dry mill, Fig. 6, having a capacity of 700 tons of feed per day from which 300 tons of titanium mineral concentrate and 120 tons of staurolite is extracted. Two methods of concentration are used: high tension, an improved form of electrostatic separation, and high intensity magnetic separation, see Fig. 7.

The feed is dried and heated to approximately 220°F and transported to the mill by shaking conveyors. It is elevated by bucket elevators to screw conveyors which deliver the feed to bins over each concentrating unit. Horizontal belts underneath the units gather and transfer the various products.

Titanium minerals are separated from the silicate minerals by high tension separators. Sixty-two of these units are arranged in four groups for roughing, scavenging, and cleaning steps as shown in the flowsheet, Fig. 1. In this type of separation the minerals are fed onto a high-speed spinning rotor, and a heavy corona discharge is aimed toward the minerals at the point where they would normally leave the rotor. A 40,000-v pulsating dc is used.

The minerals of relatively poor electrical conductivity are pinned to the rotor by the high surface charge they receive on passing through the high voltage corona. The minerals of relatively high conductivity do not as readily hold this surface charge and so leave the rotor in their normal trajectory. In this particular operation the titanium minerals are the only ones present of relatively high electrical conductivity and are, therefore, thrown off the rotor. The silicates are pinned to the rotor and are removed by a fixed brush.

In the rougher stage, where the minerals are the hottest, the non-conductor minerals are pinned so strongly to the rotor that it is difficult to brush them off. This problem has been overcome by the use of a second electrode with a high voltage alternating current which discharges the grains, allowing them to be removed easily.

Titanium minerals from the high-tension separators are treated by induced roll magnetic separators to produce ilmenite at 63 pct TiO_2 and a non-magnetic fraction, largely leucoxene, which after two-stage high tension cleaning contains about 80 pct TiO_2. The titanium mineral products which contain less than 2 pct silicates are shipped in hopper-bottom covered cars to E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.

The silicate reject from the high-tension scavengers is further treated on induced roll magnets to produce a magnetic fraction which is largely staurolite but also contains some tourmaline. This product contains more than 45 pct Al_2O_3 and is used by a Florida cement plant as a source of alumina in the mix instead of the customary clay.

Zircon Plant: Humphreys Gold Corp. operates a separate plant, Fig. 8, to recover the zircon contained in the ilmenite-staurolite tailing. The tailing is re-spiralled to remove quartz, kyanite, sillimanite, and other minerals that cannot be separated by dry methods. The spiral plant uses 120 spirals arranged in four stages and produces a concentrate containing about 90 pct zircon and less than 1 pct of either quartz or non-magnetic aluminum silicates. Fig. 9 shows the interior of the zircon plant.

The spiral concentrate is dried and heated to 1200°F in a rotary oil-fired counterflow dryer to remove the small amount of organic staining which discolors the surface of the zircon grains. This calcining results in a snow-white zircon product.

The discharge from the drying-calcining operation is elevated to the dry plant feed bin by an air lift which also acts as a cooler. In the dry plant 16 high tension separators are used to remove residual titaniferous minerals. Further treatment on two induced-roll magnetic separators removes non-conductor magnetic minerals, mainly staurolite and tourmaline. The non-magnetic fraction, 98 pct zircon, is packed in paper bags of 100 lb each. The plant has a capacity of 2500 short tons per month. The zircon product is marketed for foundry, ceramic, and high temperature use, and for special sandblasting.

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National Lead Co. Mechanization At Fredericktown, Mo.

by Harold A. Krueger

FACILITIES and mining operations of the National Lead Co., St. Louis Smelting and Refining Division, near Fredericktown, Mo., are situated in a famous mining area. Copper, lead, nickel, and cobalt have been mined here for more than 100 years, work having been started on a high sulphide copper outcrop in 1847.

Lamotte sandstone is characterized by differential compaction on a rigorously eroded pre-Cambrian surface. The Bonneterre formation was therefore a good host for minerals not generally found in mineable quantities in these midwestern areas. Unusually complex minerals, however, make beneficiation difficult, and because of irregular ore thicknesses and elevations many engineers and operators have not attempted to mine the property. Others have tried who failed.

This paper deals with economic, efficient, and competitive methods of mining these highly irregular orebodies, as compared to the open-stope, room-and-pillar methods normally used for horizontal-bedded lead deposits.

For the purpose of this study it should be understood that the ore is found in two distinctly different types of occurrences, one to be designated as *basin ore* and the other as *contact ore*. Mining of basin ore is complicated by many faults, fractures, cross faults, and breaks. Contact ore is complex because it is found on flanks or slopes of pre-Cambrian knobs or highs. The dip of the mining floor for the latter type varies between 18° and 45°.

Occurrences of both types of ore are complicated by water courses or solution channels which carry unconsolidated shale, lime, sand, and dolomite. This material is also found between the bedding planes of the members of the Bonneterre formation. The water found where there are fractures, faults, and channels makes it very fluid and tacky, see Fig. 1, particularly after it has been blasted and handled by loading and hauling machines. Much of the ore can be wadded and thrown without dispersing.

During early operations by the Buckeye Copper Co. in 1861 and the North American Lead Co. from 1900 to 1910, conventional narrow-gage railroad and side dump mine cars were used with hand shoveling. The complications of mining the contact ore, the only type attempted at this time, can be appreciated when it is realized that operators were obliged to use mules for haulage. Haulageways constructed on these slopes were of necessity similar to wagon trails or goat trails up the side of a mountain. In other words, it was merely a matter of going from side to side of the strike length of the slope, gaining a little in elevation on each shuttle trip. Production totaled only one to two tons per manshift.

A few years later, about 1913, the property was purchased by combined Canadian interests known as the Missouri Cobalt Co., and the use of trolley locomotives was initiated.

Between 1900 and 1928 a land agent using churn and diamond drilling methods prospected scattered sections of the area. In 1928 the first property was purchased by the present company, then operating as the St. Louis Smelting and Refining Co. Check drilling and prospecting was carried out by the company at various times between 1928 and 1939 to correlate the erratic mineralization. Much information about both types of orebodies was accumulated, but it was still questionable as to whether money should be invested to work these occurrences.

In anticipation of high lead and copper prices, about the time World War II started, it was decided to develop and bring into production some of this ore. In 1942 No. 1 shaft was put down on the largest basin-type orebody and in 1943 No. 2 shaft was put down on contact-type ore. Operations were expanded when No. 3 shaft was completed in 1943, and progressed further in 1948, when National Lead Co. dewatered and opened No. 5 and 6 mines, old workings of the North American Lead Co. and the Missouri Cobalt Co.

Because of the differential compaction of Lamotte sandstone over the pre-Cambrian porphyry, in some instances mineable thicknesses of basin-type ore occurred 20 to 30 ft above the sand. This is the exception rather than the rule, since most of the mineralization starts at the sand and is variable in thickness. The ore was attacked, therefore, by development drifts and crosscuts at the lowest possible elevation, where the ore immediately overlying the Lamotte sandstone could be drained and made accessible for mining. It was planned to connect to the drifts and crosscuts with raises to mine ore deposited 20 to 30 ft higher. The higher orebodies were thus mined as slusher levels. Slusher hoists were used to drag the ore into the raises, which were made into hoppers. The ore was then loaded into 32x32-in. ore cans, hauled to the shaft by battery locomotives, and hoisted by the conventional Tri-State method. The rate of efficiency was 5 to 6 tons per manshift underground.

The contact-type ore was attacked in a similar way, except that the orebodies were not nearly so wide, so that they were more flexible for slusher loading into *cans*. This advantage was offset, however, by haulage complexities, since the railroad was constructed on steep slopes.

Through experience and ingenuity, many improvements were made in mining both types of ores. The two levels, so-called, in the basin-type orebodies were connected as previously planned, more efficient locomotives replaced the older ones, and a

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Fig. 1—Mud condition caused by water present where there are fractures, faults, or channels.

better shaft-switching system was used prior to hoisting the cans. In the early stages of mining, the upper and lower ore did not connect in all instances, but where it did, the resulting abrupt change in floor elevation was leveled off by means of railroad fill whenever possible. Improvements in draining the mine of muddy, sandy water also contributed to the steady increase in operating efficiency, which from all indications had reached a maximum, 8 to 10 tons per manshift underground, by the middle of 1949.

With the years 1944 to 1947 used as a based period, the average yearly grade of ore, total mining cost per ton, labor cost per ton, labor rates, materials cost per ton, and material cost and tons per manshift have been plotted on a line graph, Fig. 2. This shows the trends existing during the five-year period from 1947 through 1952.

The year 1947 was chosen as a starting point because it was then obvious to operators everywhere that to cope with the high operating costs of low-grade nonferrous metal mines it was going to be necessary to improve mining methods. A general decontrol, the ending of the Premium Price Plan and the thawing-out of prices, and the close of the post-war boom occurred at this time. Mine operators were left with a low lead price and high costs for labor and materials. Fig. 2 shows the improvements made between 1947 and 1949 under the Tri-State car and can haulage system.

Necessary Mechanization

In 1949 another operating crisis was experienced. Cost and efficiency improvements had reached their limits, and it was necessary to head off the surge toward increased costs. This is demonstrated in Fig. 2 by the constant rise in labor and material costs and the flattening of the efficiency curves.

Many solutions to the problem were considered, but it was obvious after the study that the hauling and hoisting complications were the major items of the mining cost figure. Other costs could probably be held if these were reduced. After a consideration of ore reserves and the economics of each plan, it was decided to connect No. 1 and No. 5 mines by a 950-ft tunnel driven in such a way that it could be utilized for diesel truck haulage from the No. 1 mine to No. 5 mine shaft. Fig. 3 shows the tunnel connecting these mines and the haulage roads and old railroads. This system was chosen because the conventional two-ton balanced-skip hoisting-shaft, available for use at the No. 5 mine, eliminated the use of one *can* shaft of low capacity. The 18x14-ft tunnel was driven with a 104 Eimco diesel-mounted loader and three Koehring dump trucks, at an average daily advance of 11 ft. The tunnel was ventilated with a rubber-impregnated sail pipe. No churn drill hole could be driven from the surface because the tunnel

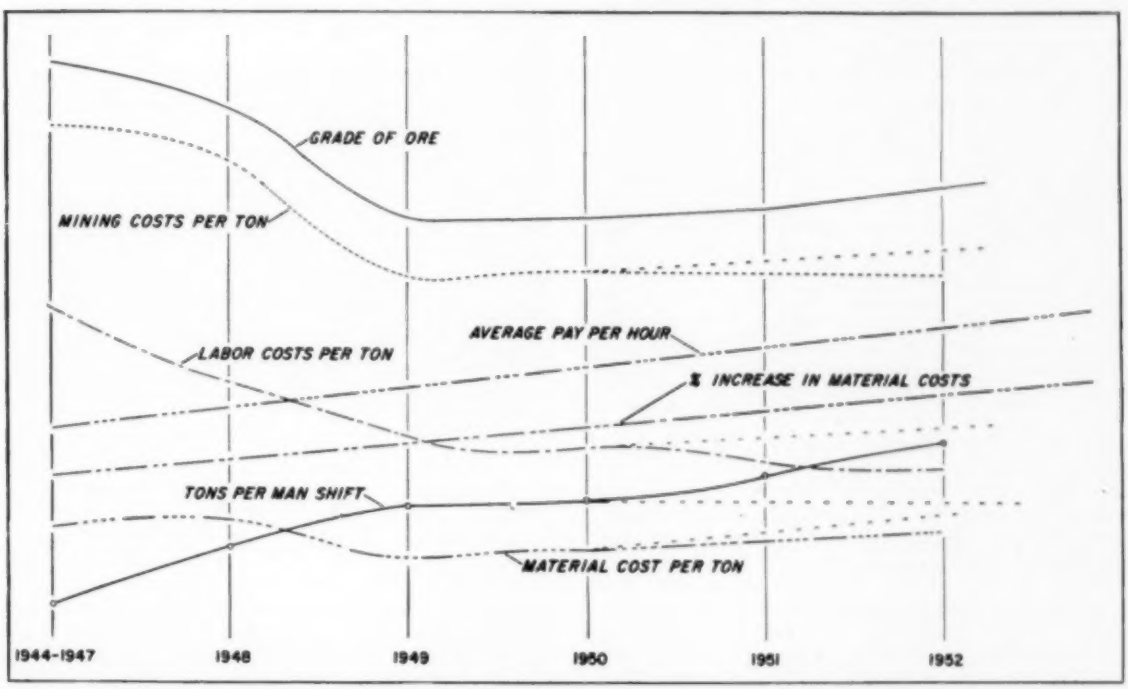

Fig. 2—Total mining costs during the 5-year period 1948 to 1952. The years 1944 to 1947 were used as a base period.

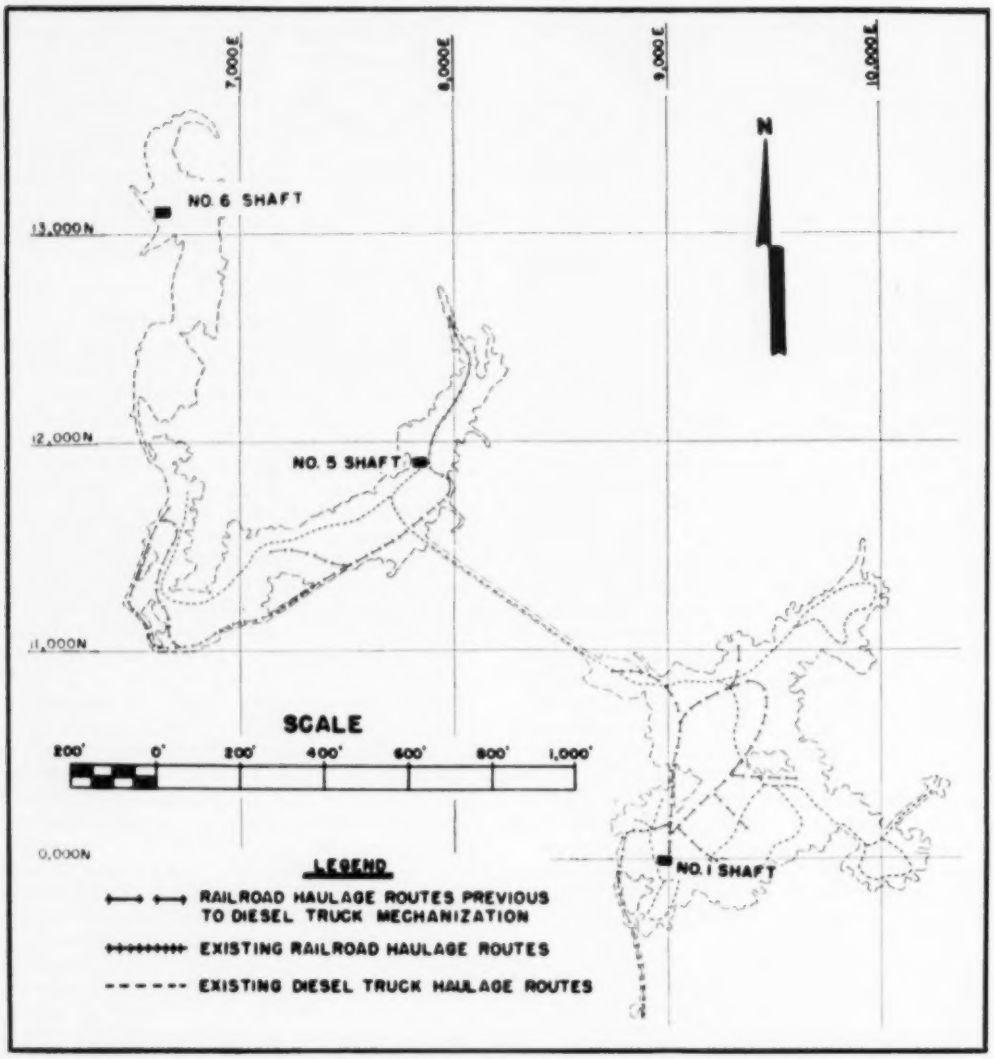

Fig. 3—Underground haulage routes, No. 1 and No. 5 mines. A 920-ft tunnel connects haulage routes and old railroads.

was under the reservoir which was used for storing mill tailings.

The drift work was carried on from the southeast end or No. 1 mine side on a contract basis. To speed the completion of the job, work was done simultaneously at the northwest end, or No. 5 mine side, on a daily pay basis. The ancient haulageways and mining and the conflict in production did not permit easy movement of equipment for disposal of waste rock from the drift on the No. 5 mine side. A unique system was devised to overcome this bottleneck, utilizing a D-4 bulldozer equipped with a three-drum slusher hoist mounted on the back opposite the blade. The broken rock from the night before was pulled back with the scraper, and the jumbo used for drilling the drift rounds was driven over the broken muck pile. In this way it was possible to begin drilling sooner after the shift started than it would have been with ordinary methods. The D-4 bulldozer then pushed the muck out of the portal into the adjacent old stope. This system was used on the northwest end for a distance of only 200 ft, which was the limit economically for pushing the muck with the bulldozer, but it speeded the job to completion. Fig. 4 shows the high-lift type of machine, an Allis-Chalmers HD-9, used for loading, road building, and bulldozing.

The connecting tunnel, as well as roads around No. 1 mine, was completed and surfaced with drift rock by means of the bulldozer and a diesel tandem-drive road grader. The road grader, see Fig. 5, is still used for maintaining roads and the bulldozer for constructing new roads.

The 24x15-ft grizzly, finished at the time the tunnel was completed, received all the No. 1 mine ore, which was hauled through the lighted tunnel by Koehring 7-ton trucks. Fig. 6 shows the grizzly and Fig. 7 the dumptor truck discharging on screen.

The practice of using crawler-mounted jumbos was initiated in 1950, and started the trend toward improved breaking efficiency. Prior to this time drilling was done with a conventional post-mounted air-fed 2¼ or 2½-in. jackhammer devised years ago by St. Joseph Lead Co. The drilling problem as yet has not been solved, but there are constant improvements in jumbo results and jacking experiments.

Fig. 4—A high-lift machine used for road building and bulldozing also serves as emergency loader.

Fig. 5—This diesel tandem-drive road grader is used for maintaining roads and a bulldozer for building new ones.

Fig. 6—The 24x15-ft grizzly was finished at the time the tunnel was completed and received all No. 1 mine ore.

Fig. 7—Dumptor truck discharging on screen. The Koehring dumptor has a 7-ton capacity and a loading height of 8½ ft.

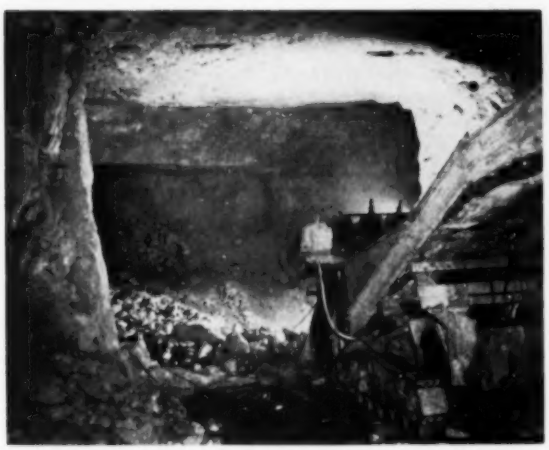

Fig. 8—A crawler-mounted slusher hoist improved efficiency nearly 100 pct.

Fig. 9—Scraper loading into haulage truck, which has a loading height of 5½ ft. Note low headroom.

After the changes were made the No. 1 mine, producing 68 pct of the total plant output, showed improved efficiency, as indicated in Fig. 2 by the break in the lines after the year 1950.

No. 1 mine hoisting cost was greatly reduced by the utilization of the centralized hoisting system at No. 5 shaft. Manpower requirements were also reduced in the loading and haulage segments of the mining operation. The 104 Eimco, used to drive the connecting drift, was employed on production where headroom and floor conditions were applicable. Tons per hour handled with this machine were as high as 100, but mud and irregular floor conditions resulted in high maintenance. It was then ear-marked specifically for development work, and only in emergency for production. Loading of the major part of the production was continued with the crawler-mounted slusher hoists and scrapers, see Figs. 8 and 9. Effi-

ciency with the slusher loader was improved almost 100 pct. Slushing into cans on railroad track limited the operation to the railroad and to use of small ore cans. Dragging time from face to rail-loading point was long in most cases because of the difficulty in building good railroad grade to within 50 ft of the face, especially over faults and breaks. Now, with drag loaders able to handle broken ore immediately in front of the machine, cable cost has been reduced 35 pct.

Haulage cost was lowered 50 pct immediately because the Koehring dumptor truck could negotiate grades of 8 to 12 pct over faulted areas. With the railroad system, an abrupt change in elevation necessitated moving hundreds of feet of track and building a fill to keep the grade under 3 pct.

Maintenance cost for locomotives, cans, and rail trucks on which the cans were hauled had been high, since track and cleanup crews constantly had to repair track and clean mud from moving parts of the equipment. Now the road grader keeps roads smooth and clean of rocks and mud. The Allis-Chalmers HD-9 makes fills or cuts very efficiently and is used with bulldozer attachment for dozing work. In Fig. 4 it is shown in emergency use as a loader, but this is not recommended, since track repair cost is too high.

Because the mechanized system had proved flexible and efficient, it was decided in 1951 to mechanize the No. 5 mine, developing from No. 1 mine the ore reserves being mined from No. 2 shaft, and closing No. 2 mine down.

A Low Headroom, High-Capacity Haulage Unit

Several problems were encountered in mechanizing the No. 5 mine. There was a low headroom of 8 ft, a long distance of 2300 ft around the porphyry contact, and grades to be negotiated. (The railroad system in use at this mine is shown in Fig. 3.) The orebodies require relatively close pillar spacing in some places where faulting and fractures have made it necessary, and therefore space for turning any equipment chosen was also a serious problem. This meant that a haulage unit must be devised with a speed equal to that of the dumptor, capable of carrying a load which would compensate for the distance traveled. The unit must have a small turning radius, a maximum loading height of 5½ ft, and a maximum headroom of 8 ft when occupied by the driver. It must be constructed to discharge on the large grizzly over the skip pocket at the shaft, as shown in Fig. 6.

The equipment chosen was a Caterpillar DW-10 rubber-tired tractor, diesel-powered, with hydraulic steering, pulling a newly designed, heavily constructed semi-trailer. This equipment was designed jointly by National Lead Co. personnel and Miles Landis of the Landis Steel Construction Co. of Picher, Okla. The trailer, which handles 14 to 17½ tons live load, was designed with hydraulically controlled side dump. Loading height is 5½ ft. The goose neck coupling between trailer and tractor was made especially heavy to reduce height and improve strength. This haulage machine, shown in Fig. 10, met the demands of the various problems.

Like the Koehring dumptor, which has a capacity of 7 tons and a loading height of 8½ ft, this unit has proved extremely rugged and flexible. Each unit has a speed of 18 mph. The average haul from any room or stope in the mine is more than ½ mile. The time required for a DW-10 tractor-trailer or a Koehring unit to make a complete trip is about 20 min. This haulage time, of course, is dependent upon the particular conditions under which the loaders are working, namely, ore fragmentation, size of muck pile, accessibility with trucks, type of loader, and headroom and pillar spacing. It is not uncommon for three trailers operating under the conditions described here to deliver to the skip pocket 600 tons of ore in an 8-hr shift, the Koehring trucks supplementing the production where conditions require. It must be remembered that here, as in all mining operations, only 5 to 6 actual hours of work are realized in an 8-hr shift. Lunch hours, transportation time to and from working places, and time for greasing equipment must be taken into account.

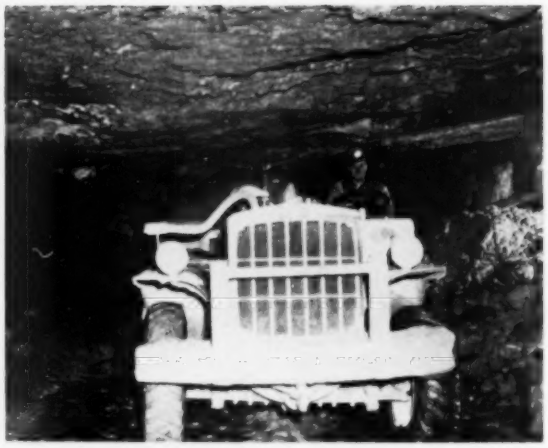

Fig. 10—Haulage machine designed to meet the problems encountered in National Lead Co. mines.

Attention is called to the adaptability of the two types of trucks, with emphasis on the efficiency of the smaller Koehring truck for development work. The short turning radius of 19 ft 6 in., together with the Koehring-designed driver position with respect to the load, are particularly advantageous for mine development. Experienced driver control in spotting these units around closely spaced pillars and under loaders is almost uncanny.

The DW-10 trailer unit, which is 35 ft long and 7 ft wide, requires more room for maneuvering, but here again, drivers can back or jack-knife the long trailer into a very small space. This is possible because of the 26-ft turning radius of the tractor and the hydraulic steering. Naturally it will become increasingly desirable to use this larger unit as haulage distances become longer, since it operates at lower cost per ton than does the Koehring truck.

The necessary variety of mine loaders was completed early in 1952 with purchase of the 25 TL Thew-Lorain turntable shovel, which has a 1½-yd capacity front-end loading boom. The Lorain shovel is applicable where headroom is sufficient, i.e., 9 ft 6 in. or more, and where the capacity can be utilized so that it does not affect the grade of ore too greatly. (This last condition is essential because the complex minerals must be fed to the concentrator in a constant grade of feed.) Drag loaders or Allis-Chalmers hydraulic high-lift loaders are utilized in working areas with lower headroom. The 104 Eimco is specifically assigned, as mentioned earlier, to development work in cuts, drifts, crosscuts, and narrow stopes.

Supervision of mechanized operations is extremely important, and foremen are equipped with jeeps

for greater efficiency. One foreman supervises loading, hauling, and hoisting, and another supervises drilling and breaking. This kind of leadership is not feasible in railroad mining operations.

The Underground Maintenance Shop

The maintenance department has been located at a central point for efficient performance. Here, as in many other mines throughout the country, all fabrication, welding, drill steel preparation, and rock drill, truck, loader, and jumbo repair are carried out in the shop. Maintenance rather than repair is emphasized because the sand-impregnated mud already mentioned finds its way into all moving parts of the mechanized equipment. It has been found that regular greasing keeps the mud out of bearings and moving parts, so that maintenance cost is reasonably low. Inspection reports are maintained, showing precisely the quantity and type of work performed on each piece of equipment and the number of hours of operation since the same work has previously been performed. Constant checks are made on motor efficiency and fuel and oil consumption, and exhaust fumes are kept within Bureau of Mines regulations at all times.

The ventilation system devised has eliminated the necessity for an exhaust treatment system on the production equipment. Fresh air forced down inactive shafts and some drill holes is picked up by underground circulating airplane-type fans, discharging at the hoisting shaft at No. 5 mine. An updraft condition exists at all times.

Spare haulage and loading units are kept in supply so that complete overhaul and maintenance practices can be followed. Mounted spare tires and other complete unit replacement parts are ready for quick changes when problems occur. The excellent tire wear and low tire replacement cost should be mentioned at this point. The 18x25 tire withstands the severe punishment of underground haulage. Replacement cost is low and in most instances the carcasses can be recapped with satisfactory results.

In summary it can be stated that if the mechanized system had not been adopted, the mining operations described here would probably not have survived the low lead prices between 1949 and 1952. It can be seen by a study of Fig. 2 that if costs had increased steadily, the cost curve would have intersected the grade of ore curve. Since grade of ore could not be increased, continued operation would not have been economically feasible.

Although actual mining cost per ton was not reduced in proportion to the raised efficiency factor, improvements made in ore handling, coupled with other advantages of mechanized equipment applicable to the complex orebodies of this property, made it possible to hold mining costs to a horizontal trend despite rising material and labor costs.

Prior to 1950 it was necessary to have 128 men in the mining operation, including those necessary for underground maintenance, hoisting, and grizzly. By the close of 1952 this crew had been reduced to 80 men. This reduction accounts for the upward trend of efficiency curves, Fig. 2, showing tons per manshift underground. Obviously the ideal condition would be to pay the highest possible wage and keep the mining cost curve as low as possible. It is possible to do so when the efficiency curve has this appearance.

Since the beginning of 1949, 1250 to 1400 tons of ore per day have been produced at this property. Increase in efficiency has enhanced the life of the property as well as the ore reserves. The difference between 1400 tons produced by 128 men and 1400 tons produced by 80 men is an efficiency improvement of 57½ pct.

Acknowledgments

The author expresses appreciation to Stuart Landrum, H. A. Neustaedter, T. J. Parkin, H. A. Powers, and J. A. Rood for their help in preparing this paper.

Technical Note

The Application of Geophysical Exploration in Civil Engineering

by George F. Sowers

THE geophysical methods of exploration employed so extensively in mining and petroleum investigations are now being used in civil engineering. Requirements differ from those of mineral exploration and therefore modified techniques have been developed.

The civil engineer is primarily interested in the uppermost soil and rock strata. In highway engineering the materials affecting design and construction may be found within 15 or 20 ft of ground surface, and data on soils and rocks is seldom needed for more than a depth of 100 ft even for the heaviest structures.

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Table I. Relative Merits of Geophysical Methods and Comparable Boring Methods

Method	Cost of Equipment, $	Minimum Crew	Cost Per Lin. Ft Depth, $*	Advantages	Limitations
Hand auger	10	1	0.50 to 1.00	Soil samples	Limited by gravel, ground water table; 30 ft maximum depth.
Powered hand auger	500	2	0.25 to 0.50	Soil samples	Limited to 6 to 8 ft depth.
Truck-mounted power auger	3000	1	0.30 to 1.00	Soil samples Washed samples	Limited by boulders and ground water.
Wash boring	500	2	0.30 to 1.00	Not hampered by boulders	Cannot bore gravel.
Seismic	4000	3 to 4	0.25 to 0.50		Confirmation by boring necessary. No good if rock surface is irregular. Soil character only estimated. Requires explosives.
Resistivity	500	3 to 4	0.25 to 0.50	Not hampered by boulders	Confirmation by boring necessary. Soil characteristics estimated. Affected by strong electric current.

* Commercial cost including overhead and reporting of data.

The data required are depth and thickness of soil strata; composition and engineering properties of the soils, such as strength, permeability, and compressibility; depth to the rock and soundness of rock; and depth to ground water. In preliminary design stages data need be only approximate, whereas for the final design accurate detailed statistics are necessary.

Three methods have been found useful in civil engineering investigations: the variable-spacing-electrode resistivity, the constant-electrode-spacing resistivity, and the refraction-seismic. Others such as the various gravity measurements and the reflection-seismic have found only limited use in special situations.

The variable-spacing-resistivity method has frequently been employed in determining depth to bed rock and depth to ground water. It has been particularly useful in preliminary surveys of highway routes, when it is necessary to estimate the amounts of rock excavation over extensive areas. Occasionally the method has been used to determine depth and thickness of different soil strata, but only when the soils are relatively horizontal and uniform and when the resistances of the strata are widely different.

The uniform spacing or traverse method involves determining resistivity for constant depth over a wide area. Contour maps of high and low resistivity are then prepared which define areas having shallow or great depth to rock. Such maps have also been used to locate sources of sand and gravel, since these materials, when dry, have relatively high resistances.

The refraction-seismic method has been widely employed to determine depth to bed rock, especially where that depth has been 50 ft or more. It has been used with great success in exploring possible dam sites in areas where deep deposits of sands overlie the rock. The method will differentiate between dry gravel and rock, as the resistivity method may not do, and is especially advantageous for soils containing boulders, which can hinder drilling operations seriously. It has also been used to determine the boundaries of soil strata; in some cases it has been possible to identify the soils by their characteristic velocities.

Unfortunately the civil engineers who must decide which kind of exploration to employ have sometimes been oversold on the advantages of geophysical methods, which like any other indirect method have inherent weaknesses. They have not understood the limitations of the data obtained, and as a consequence engineers have been disappointed or dissatisfied with the results. To prevent misunderstandings, geophysicists who work with civil engineers should forewarn them.

In the first place, geophysical exploration provides the engineer with only part of the underground data he needs for design. It can indicate depth to rock and to ground water and in some instances can develop the stratification of soils, but it cannot identify materials accurately or indicate their physical properties. These data must be obtained by other methods.

In the second place, geophysical exploration sometimes provides inaccurate or misleading information when underground conditions are erratic or otherwise unsuited to the work. Unfortunately it is not always possible to determine unsuitability ahead of time. On one job in North Carolina seismic exploration indicated sound rock at a depth of 30 ft but subsequent exploration disclosed it at 15 ft, an error of 100 pct. On a site in Georgia the average error in determining depth to bed rock by electrical resistivity was 160 pct of actual depth and the minimum error 40 pct. In both instances the work was done by experienced crews under the supervision of geophysicists. Before any engineering work based on geophysical exploration is undertaken, borings should be made to confirm the data, and the entire project should be reviewed by competent geophysicists, geologists, and engineers.

In some situations characteristics of the site may prevent any geophysical work. Seismic work is ordinarily impossible in cities because of regulations regarding the use of explosives. On a few sites, electrical current in the soil renders accurate resistivity measurements impossible. For example, measurements made in an old fill to determine depth to virgin soil proved so erratic as to be worthless. The cause was deduced to be electrical currents generated by acid cinders in contact with junk metal that comprised what had been an old rubbish dump.

Information obtained by geophysical exploration is in many ways comparable to that obtained by wash boring and auger boring. The decision to use geophysical methods or direct methods depends largely on convenience and cost. Advantages of various methods are compared in Table I. In general geophysical equipment is expensive and relatively complex. Trained personnel and experienced supervision are needed to obtain satisfactory results. On the other hand, an experienced crew is able to secure large amounts of data in a short time.

Auger and wash borings utilize relatively simple, rugged equipment which is available on almost any fair-sized construction job. Even non-professional men can usually obtain good results. Shallow work can be done quickly, but when depths greater than 100 ft are involved and when coarse gravel and boulders are encountered, progress may become slow, if not impossible.

Laboratory Procedures For Determining Pelletizing Characteristics Of Iron Ore Concentrates

by T. E. Ban and L. J. Erck

A discussion of laboratory procedures used to determine pellet quality and to simulate handling and firing conditions. Strength-temperature relationships in pelletizing; effect of chemical additives on agglomeration; and crushing, abrasion, and impact resistance of the pelletized products are discussed with respect to five different iron ore concentrates.

IN most routine experimental work on products and processes, methods of operation and product evaluation are established from accurately controlled laboratory tests. With particular emphasis on the pelletization of fine iron ore concentrates, standardized procedures of laboratory production and product testing have been established at Cleveland-Cliffs Iron Co. Research Laboratory at Ishpeming, Mich. A program of this nature was used for investigating the agglomeration characteristics of various iron ore concentrates. The factors which control the process were studied and subsequently controlled for these investigations.

Pelletizing as applied to iron ore agglomeration involves the preparation of spheroidal masses from a fine moist concentrate, followed by high-temperature firing to produce a final product. The preparation of moist spheroids is generally designated as *balling*. This produces the so-called green pellets or balls. After these have been fired they are called *pellets*. Balling is accomplished by rolling moist concentrates in a revolving drum until small spheroids form by a snow-balling action. These balls are then heated in a shaft furnace, or a modification of this device, to a temperature high enough to cause agglomeration within the individual balls while they descend countercurrent to hot oxidizing gases. By this process the low strength balls are converted through various chemical and physical-chemical processes into hard pellets. With correct balling and firing, the pellets are strong, resist abrasive action and handling treatments, and provide a suitable blast furnace and open hearth feed.

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In 1950 Tigerschiold and Ilmoni developed a working hypothesis to explain the formation and stability of green pellets.[1] Their work was presented on the basis of geologists' discoveries concerning the soil-water system and C. V. Firth's early postulates of green pellet formation.[2] Fundamental reactions occuring within fired pellets have been described by Cooke and Ban, who showed the microstructure changes caused by different firing temperatures.[3] All these investigators have provided scientific clarifications of agglomeration by the pelletizing process and have opened avenues for greater development.

Mineral grain growth and ceramic bond formation are the two basic phenomena imparting coherency to particles within a fired pellet of iron ore. Each of these is established by the transfer of thermal energy to the mineral particles. Grain growth mechanisms are chiefly physical reactions wherein smaller particles consolidate into larger ones, with resulting decrease in surface energy conforming with the second law of thermodynamics. Ceramic bond formation is a chemical reaction usually between basic and acid metallic oxides of the gangue and ore minerals. CaO, MgO, Al_2O_3, and FeO of Fe_3O_4 react in varying proportions with SiO_2 or Fe_2O_3 to form a great series of compounds or amorphous solid solutions. These product bond iron mineral particles together by a bridging action or by direct reaction with the surfaces of the particles. The result of the grain growth-ceramic bond formations is a consolidated, coherent compact of gangue and iron minerals formerly held together by much weaker bonds of interstitial water and forces common to dry, unconsolidated particles.[4] With respect to iron ore agglomeration, these high temperature bonding reactions have been described by Schwartz, who referred to the bonds in sinters,[5] and by Cooke and Ban, who referred to the bonds in fired pellets.[3]

The extent of the bonding phenomena and the consequent strength of fired pellets is governed by

some of the following firing conditions and properties of the unfired pellet: 1—mineralogical composition of the pellet, 2—particle packing within the pellet, 3—particle size range of the minerals comprising the green pellet, 4—maximum temperature to which the minerals are exposed and the retention period at this temperature, 5—the rate of attainment of and rate of recession from the maximum temperature, 6—the gas composition of the atmosphere in which the pellet particles are fired, and 7—the high temperature chemistry of the mineral particles and the additives of the pellets.

The mineralogical composition of the concentrate denotes the quality and quantity of thermally active compounds. Acid and basic oxides when present in critical amounts will materially promote interparticle consolidation by a ceramic bond formation, and iron minerals have grain growth properties peculiar to the ore. If the gangue constituents are present in abnormal quantities, pronounced slagging will occur within the fired pellet, and iron particles will be weakly bonded by excessive glassy constituents which inhibit the iron particles from interlocking by grain growth.[6]

Thermal barriers must be overcome before many ceramic reactions occur. The free energy of a chemical reaction must be of a negative value before the reaction occurs, and the greater the negative value the greater the reaction tendency becomes. At constant entropies and enthalpies, a negative free energy of reaction becomes more prominent with increasing temperature. A higher temperature generally increases a chemical reaction tendency and rate. This same higher temperature generally increases particle mobility and solid diffusive characteristics contributing to the grain growth mechanism.

A rapid rate of temperature increase lessens the compaction of a green pellet, owing to the rapid expulsion of air or bound water. This causes mineral particles to become less intimate for the bonding reactions. A rapid temperature increase also causes a duplex structure to result within a green pellet of magnetite. If sufficient heat is transferred to the center of a pellet prior to oxygen diffusion and magnetite oxidation, the core will consolidate to coarse-grained magnetite, while the shell or outside surface oxidizes to hematite. The coarse-grained magnetite core becomes less susceptible to subsequent oxidation by virtue of the coarse structure and the presence of slag coatings caused by the reaction of FeO with SiO_2. The duplex-structured pellets, hematite shell somewhat separated from a magnetite core, have a lower strength index than pellets containing an homogeneous network of iron oxide. Rapid cooling of heated iron ore pellets causes bond and lattice strains from differential thermal contraction. This is common to quenched vitreous materials.

If the atmosphere of the fired iron ore particles is not of homogeneous composition, differential agglomeration will come about within the pellet because of particle chemistry differences. Hematite, magnetite, and the lower oxides of iron definitely possess different properties of agglomeration. If some of the iron minerals are contiguous to reducing substances during firing, the agglomeration characteristics will differ from particles fired in an ambient atmosphere that is oxidizing in nature.

In a generic sense, ideal agglomeration is afforded by the following conditions: 1—the presence of an optimum quantity of slag-forming constituents within the concentrate, 2—the use of an optimum firing temperature, 3—a slow rate of temperature increase during firing, 4—a slow rate of temperature decrease after firing, 5—a long retention time at the optimum firing temperature, 6—a high degree of compaction, and 7—an homogeneous oxidizing ambient atmosphere during the firing period.

The Cleveland-Cliffs Research Laboratory staff has developed an apparatus for evaluating the relative response of various fine concentrates toward pelletization and for enabling a study of the various additives or factors which aid the process. This apparatus was designed and operated to simulate the conditions imposed by the shaft furnace firing of iron ore pellets. For this purpose, some of the operating conditions of a pilot plant shaft furnace were obtained and incorporated within the laboratory device.

Shaft furnace firing of green iron ore pellets is carried out by the placing of wet pellets on the top of a shaft hearth containing pellets in the process of being fired. As the charge descends into the shaft by gravity, the wet pellets are fired by a countercurrent stream of combustion and heat transfer gases. Varying temperature zones within the furnace perform the following consecutive operations on the descending wet pellets: 1—drying, 2—preheating, 3—firing to a maximum temperature, and 4—cooling.[7]

The regions of the hot zones depend upon the temperature of the hot gases, the chemistry of the pellets, and the rate of descent and ascent of the pellets and gases respectively. Ideal shaft furnace operation requires isothermal temperature zones transverse to a path of uniform gas flow and charge descent. It is very difficult to obtain these conditions because of pellet particle segregation and inter-pellet consolidation, both of which disturb ideal gas flow and temperature patterns.

The regions of different temperature zones within the furnace shaft can be varied by operational controls, but a specific zonal region can also be a function of the high temperature chemistry of the ore pellets. If pellets contain an intrinsic fuel, magnetite or an additive which can exothermally oxidize with the gases, a hot firing zone can literally be *floated* within the shaft when relatively low temperature gases are allowed to ignite the pellet burden and maintain continual combustion within the descending charge. In this manner descending pellets of magnetite can be ignited with oxidizing gases of 1000°C and a zone of burning pellets can be established that is 1300°C in temperature. The position and maintenance of this zone gives rise to a longitudinal temperature gradient within the furnace shaft, which consequently describes the changes of pellet temperature with time.

The locations and temperatures of various zones in a pilot plant shaft furnace were determined with probing and stationary thermocouples during many pelletizing tests. From these data and from the geometry of the furnace shaft, the rate of pellet temperature change, Fig. 1, was computed. The two curves of Fig. 1 show the results of these computations from furnace tests using pellets of hematite and magnetite. The hematite pellets contained no fuel and the maximum temperature was imparted entirely from the temperature of the hot gases from the combustion chamber. For this reason hematite pellets had a relatively low rate of temperature increase. Magnetite pellets, on the other hand, burned in a zone above the entrance of the hot gases and gave rise to a rapid temperature increase. The rate of temperature decrease was approximately the same,

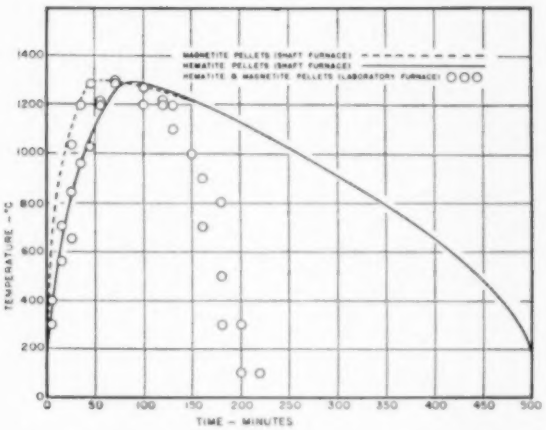

MAGNETITE PELLETS (SHAFT FURNACE)
HEMATITE PELLETS (SHAFT FURNACE)
HEMATITE & MAGNETITE PELLETS (LABORATORY FURNACE)
TEMPERATURE - °C
TIME - MINUTES

Fig. 1—Time-temperature relationships during pilot plant and laboratory firing of iron ore pellets.

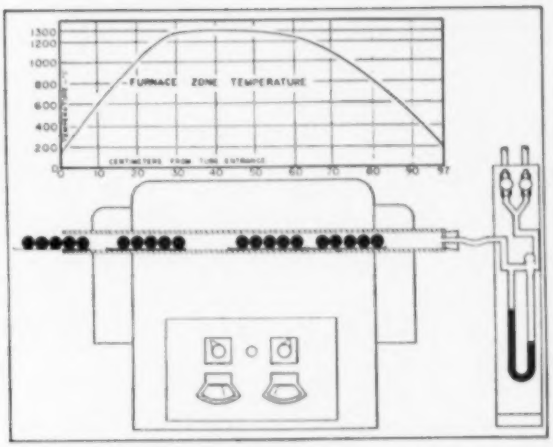


Fig. 2—Apparatus for firing iron ore pellets.

however, regardless of the kind of ore comprising the green pellet.

Air and fuel oil combustion products were the principal gases used for the pellet heat transfer and firing medium respectively. The heat transfer gases were admitted to the pellets from the furnace bottom and ascended countercurrent to the shaft burden in a quantity which was adjusted to the specific heat capacities of ore and air. These are 0.262 to 0.268; usually, therefore, 1 lb of air was used to abstract the heat from 1 lb of ore pellets. The combustion gases were transversely admitted to the pellets in the upper portion shaft in a quantity adjusted to the thermal requirements of the pellets. This quantity naturally varied from test to test, but averaged about 0.8 lb of combustion products to 1 lb of pellets. The composition of the combustion products in turn was subject to variation in that different quantities of excess air were used to provide different temperatures. Combustion products analyzed on the order of 6.42 pct CO_2, 9.4 pct O_2, 77.5 pct N_2, and 6.7 pct H_2O. Both the heat transfer gas and combustion gas mixed near the pelletizing hot zone, so that an overall 1.8 lb of gas were admitted to 1 lb of ore; the gas analyzed about 3.0 pct CO_2, 15.3 pct O_2, 78.6 pct N_2, and 3.1 pct H_2O.

Laboratory Procedure for Firing Pellets

Shaft furnace pellets undergo a temperature change with time during the transition from the wet state to the fired state in accordance with the curves of Fig. 1, and about 1.8 lb of gas containing 15.3 pct O_2 are admitted for each pound of pellet charge. This knowledge was applied to the operation of the laboratory apparatus, see Fig. 2, used to simulate the shaft furnace firing conditions. Apparatus consisted of an electrical, globar combustion tube furnace equipped with provisions for passing gas through the tube at controlled flow rates. Nichrome boats which served as the pellet-charging devices were admitted through the open end of the combustion tube, passed countercurrent to the gas stream, and removed through the upstream end of the tube. The boat charge consisted of five wet pellets, each of which was about 35 g in weight and 28 mm in diam. These were formed in a laboratory balling drum by use of procedures described by Tigerschiold and Ilmoni.[1] The drum products were stored in sealed containers and retained for the subsequent firing tests. To minimize pre-drying effects, green pellets representing a specific balling drum product were taken from the containers and placed on the boat approximately 1 min before the actual firing operation.

During operation of the laboratory apparatus pellet-laden boats were admitted one by one into the combustion tube and moved periodically through the tube so that pellets could approach the consecutive temperature changes of shaft furnace pellets. For this purpose a standardized firing schedule was developed from a knowledge of the furnace temperature gradient curve of Fig. 2 and from the heating rate curves of Fig. 1. When fired by this schedule, individual pellets were periodically changed in temperature in accordance with the circular points of Fig. 1, while a countercurrent stream of air was passed over the pellets at a rate of 3.50 liters per min. This air flow corresponded to 1.23 mols of O_2 per mol of Fe_3O_4, which in turn was roughly equivalent to the oxygen supply of iron ore pellets during the shaft furnace firing operation.

The graph of Fig. 1 denoted several instances where the laboratory firing schedule did not exactly duplicate the firing schedule of the shaft furnace. The laboratory cooling rate was more rapid, the heating rate was a mean of the pilot plant rates for hematite and magnetite, and the heating rate varied slightly from pellet to pellet.

These discrepancies were tolerable. It would have been impractical to allow laboratory pellets to cool for 10 hr, and the slight variations of the heating rates were of a small order when contrasted to the normal variations of heating rates within a shaft furnace. The results of the laboratory tests were to be relative rather than absolute. For this reason the shaft furnace firing schedule was approached but was not attained.

Pellet Quality Determinations

The quality of fired pellets can be determined by different materials tests to denote the toughness, hardness, and compressive strength. Each of these relates a measure of pellet particle coherency. Iron ore pellets should be able to withstand the crushing forces imposed by furnace and stockpile stacks and the impact and abrasive forces imposed by conventional iron ore handling and shipping. The physical properties that make it possible for pellets to endure these forces are generally related, although not def-

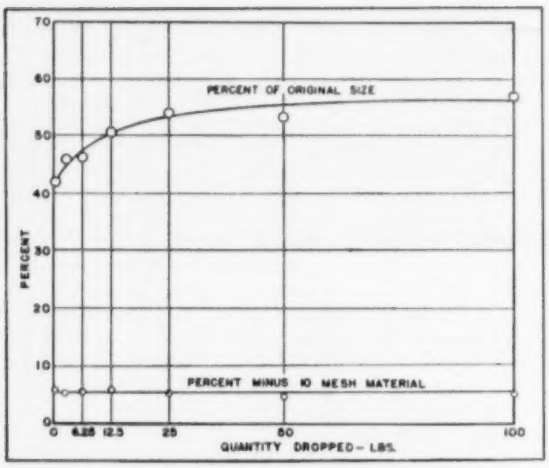


Fig. 3—Drop test relationship between pellet quantity and subdivision.

initely. Brittle pellets can conceivably withstand great compressing loads, yet will shatter remarkably from impacts. Tough pellets, likewise, can be comprised of coarse particles which readily abrade from the surfaces. For these reasons, each specific strength property was individually tested by the use of standardized materials test procedures. These were the crush, impact, and abrasion tests used to denote pellet strength, toughness, and hardness, respectively.

Strength is a measure of ability to endure stress. In the case of slow diametric compression of spherical material, stress is a function of sphere size and compressing force. When like-size spherical pellets are subjected to a slow diametric force, the strength and maximum unit stress are directly proportional to the crushing load.[6] Consequently the pellet strength designated herein was approximated from a measurement of the maximum load imposed on an individual pellet, or the extent of the compressing load which caused the pellet to crush.

The tests were performed by compressing a pellet between a hydraulic piston and a fixed steel plate. The hydraulic pressure required to crush the specimens was indicated by a Bourdon gage. The pressure was converted to pounds of load, in turn recorded as the pellet-crushing strength. Pellets representing a specific test invariably yielded strength values which were not identical. This was influenced by: 1—pellet size differences, 2—pellet shape differences, and 3—inadequate crushing techniques wherein the crushing force was not applied at a constant rate. Laboratory procedures only minimized the effect of these factors and the differences in crushing loads for pellets representing a specific batch were consequently minimized. Therefore, the average crushing load of 20 individually tested pellets was used to represent the pellet-crushing strength.

The abrasion test was developed to find a means of expressing the relative resistance to abrasive action offered by the surfaces of pellets. This abrasive action was caused by inter-pellet rubbing induced by pellet contact and movement in a small rotating drum. The drum consisted of a short cylinder mounted axially on a variable speed motor. The dimensions were 16 in. diam by 6 in. long. Exactly 1000 g of pellets, about 35 in number, were placed into the drum and the drum was rotated for 200 revolutions at 24 rpm. This rotational velocity was about 50 pct of the critical velocity so that the pellet movement was largely a cascading and rolling action. When the 200 revolutions were completed, the pellets and the fine dust produced from the test were removed and weighed separately. The weight of the abraded dust, which was all −65 mesh material, was used to express the results of the abrasion test. The intact abraded pellets and the fine dust produced from the surface were the only products of the test.

The impact test was developed for determining the toughness of the pellets or the relative resistance to subdivision from impact forces. These forces were imparted by dropping the pellets successively from predetermined height to a solid steel plate surface.

Exactly 1000 g of laboratory pellets, about 35 in number, were measured for size and placed into a container mounted 33 1/3 ft above a ½-in. steel plate surface. The container was fixed with a trapdoor exit from which the pellets were allowed to drop through a 4-in. pipe guide onto the plate. The pellets and fragments were successively dropped three times and a screen analysis through 28 mesh was made of the final product.

A strength index, or the percent of the original particle size, was computed from the screen analysis

Table I. Determination of Average Particle Size by Screen Analysis by Coghill's Method

Screen Size		Original Product			Dropped Product		
Mesh	In.	Screen Analysis, Wt, Pct	Ordinal No.* (Arbitrary)	Wt, Pct	Screen Analysis, Wt, Pct	Ordinal No.† (Arbitrary)	Wt, Pct
1¼	1.248		0	65.3	0.0	0	
1	1.050	65.3	1	69.4	8.0	1	8.0
¾	0.742	34.7	2		22.8	2	45.6
½	0.525		3		27.7	3	83.1
⅜	0.371		4		13.8	4	55.2
3	0.263		5		10.6	5	53.0
4	0.185		6		3.6	6	19.8
6	0.131		7		3.3	7	23.1
8	0.093		8		1.4	8	11.2
10	0.065		9		1.4	9	12.6
14	0.046		10		1.0	10	10.0
20	0.033		11		0.7	11	7.7
28	0.023		12		0.6	12	7.2
−28	0.023		15		5.1	15	76.5
134.7 / 100	= 1.347	100.0		134.7	413.0 / 100	= 4.130	413.0

* This ordinal number is between 1 and ¾-in. screen size. By interpolation the average size equals: 1.050 − (0.347 (1.050 − 0.742)) = 0.943

† This ordinal number is between ⅜ in. and 3 mesh screen size. By interpolation, the average size equals: 0.371 − (0.130 (0.371 − 0.263)) = 0.357

$$\text{The percent original size-strength index} = \frac{\text{Average size after impact}}{\text{Average size before impact}} = \frac{0.357}{0.943} = 37.9 \text{ pct}$$

Fig. 4a—Intact pellets before testing. Pellets of hematite concentrate, 1000.0 g, containing 2½ pct limestone and fired at 1300°C in laboratory apparatus.

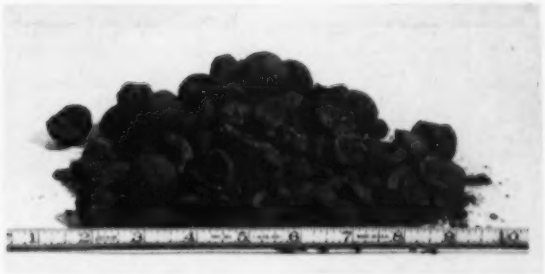


Fig. 4b—Broken pellets after drop testing, 33 1/3-ft drops onto a ½-in. steel plate surface. Drop test results: 3.5 pct —10 mesh material; 59.4 pct original size.

of the pellets before dropping and the screen analysis of the pellets and fragments after three drops. Coghill's method of mean mesh determination was adapted for this purpose.[5] This provided a means of establishing the average size of the particles directly from the screen analysis. An example of this determination is shown in Table I.

This index, along with the percent of fine material (pct −10 mesh) related the toughness of the pellets, or the ability to endure the shock of impact forces. In effect this was provided from the ratio of the average particle diameter after testing to the average particle diameter before testing.

Significance of the Product Tests

The drop tests were carried out on 50-lb samples of pellets produced from the pilot plant shaft furnace and on 1000-g batches of pellets produced in the laboratory furnace. With the percent original size as a strength index, the severity of the test appeared to be a function of the quantity of pellets used for a specific test. When 50 lb of pellets were dropped one at a time, a very small number of pellets were exposed to the greatest impact; that is, only a few pellets from each 50-lb batch received the primary impact because of the relatively small projected area directly under the drop test guide. Pellets directly on the bottom of a load received the steel plate impact, while pellets in the center or top of the load were subject to hindered falling and a resulting cushioning due to the mass effect. This dropping condition did not exist for the 1000-g drop test because nearly every pellet and fragment was subjected to an impact force which was a function only of the particle mass.

Several tests were conducted to determine the mass effect of the drop test and to determine the reliability of results procured from a specific test. Approximately 700 lb of pellets of a uniform quality were thoroughly mixed for these tests and varying quantities were cut out from the entire sample. These quantities consisted of two 100-lb portions, two 50-lb, two 25-lb, two 12.5-lb, two 6.25-lb, and eight 1000-g portions. Each portion was dropped en masse with the exception of four 1000-g portions which were dropped in a manner to conform with single particle impact. This was accomplished by individually dropping each pellet and pellet fragment onto the cleaned plane surface area. This type of drop test naturally afforded the most drastic impact, or the most favorable conditions for particle subdivision by impact. The graph in Fig. 3 shows the drop test results from using different quantities of pellets for a specific test batch. It was observed that the percentage of −10 mesh material produced from the impacts was independent of the quantity dropped, and the percent original size decreased with decreasing quantities of dropped material. This was understandable because the greater impact forces were imparted to a greater percentage of the pellet charges. The production of fines (pct −10 mesh material) was caused by both abrasion and impact, abrasion being more severe with the larger quantities. The fines produced from the impact of dropping smaller quantities of pellets were compensated for by the normal abrasion of dropping large quantities. The net result of both these effects yielded an independent value to the fines production with dropped pellet quantities.

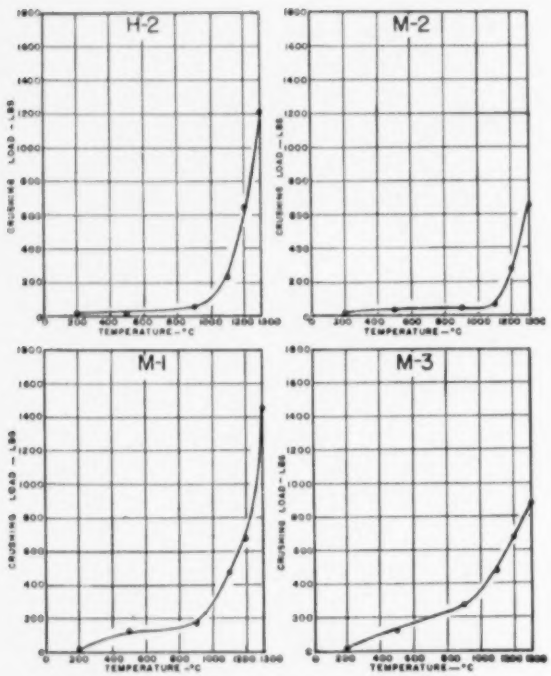
Four 1000-g batches of −1⅛ +1 in. pellets were hand picked for uniformity of quality and were given an identical drop test to determine the reliability or degree of reproducibility of the test. The results as indicated by the fines production and percent original size did not vary from an average by more than 30 or 7 pct respectively. This discrepancy was tolerable and of small enough magnitude to warrant the drop test procedure as a reliable measurement of pellet toughness.

Figs. 4a and 4b show 1000-g batches of iron ore pellets before and after the three 33 1/3-ft drop tests. These pellets were composed of fine hematite concentrate containing 2½ pct limestone and were fired to 1300°C in the laboratory apparatus. The drop test results indicated that these pellets had a relatively high impact resistance for iron ore pellets, 3.5 pct −10 mesh and 59.4 pct original size. Some direct-mined ore specimens subjected to the same drop test, −1¼ +1 in. specimens, 1000 g in weight, 3 drops of 33 1/3 ft, had a greater impact resistance than the pellets. Below are listed some drop test results on several kinds of iron ore from the Cleveland-Cliffs Iron Co.:

Item	−10 Mesh, Pct	Original Size, Pct
Cliffs shaft lump ore	2.9	79.4
Tilden siliceous ore	1.7	70.9
Cliffs group ore	9.2	28.8

Some of these relatively high values may be greater than requisite values. For this reason the drop test results from the iron ore specimens were used for comparative purposes rather than as standards for iron ore pellets.

The most expedient method of measuring the degree of particle coherency within an iron ore pellet is the crushing test. A specific test carried out as a measurement of value, such as the crushing strength of fired pellets, is only as good as the degree of reproducibility of the test. If values are assigned as crushing strengths of pellets treated in a standard manner, the values should be attained with reason-



Figs. 5 to 8—Strength temperature relationships of iron ore pellets.

able accuracy by repetition of the test. A measure of this reproducibility is denoted by the probable deviation of the mean of a series of measurements, and the magnitude of this deviation indicates the precision of the measurements. This is mathematically determined by use of the equation:

$$Q = 0.674 \sqrt{\frac{1}{N(N-1)} \Sigma r^2}$$

wherein Q equals the probable deviation of the mean value, r the residual of the measured value and the mean value, and N the number of measurements. In effect, this signifies that the probability is one to two that the mean value will have a residual denoted by the probable deviation.

Table II gives the individual crushing values of 15 kinds of iron ore pellets fired by the laboratory firing schedule to a maximum temperature of 1300°C. The significance applied to a crushing value for a series of pellets is indicated by the determination of the probable deviation of the mean of 20 individually crushed pellets. The figures indicate the average crushing values, the probable deviations of the average values, the best values, and the probable deviations of the best values stated as percentages. It was observed that the probable deviations of the best values were no larger than 12 pct and no less than 2.3 pct for the 15 sample measurements. These small deviations indicated that the laboratory firing and crushing tests were reasonably reproducible.

The abrasion resistance of pellets is dependent upon both the particle coherency and the friction factor of pellet surfaces. Coarser ore particles tend to increase the friction factor, and these coarser particles abrade more readily than equally bonded fine particles. This logic was substantiated from the comparison of abrasion test results of pellets comprised of the original ore concentrates and pellets comprised of reground ore concentrates, see Table III.

Results of Laboratory Pelletizing Tests

The laboratory tests were carried out on five different iron ore concentrates, designated as M-1, M-2, M-3, and H-1, H-2. The chemical and screen analyses of these are presented in Table IV. M-1 and M-3 represent two different concentrates of natural magnetite produced from magnetic concentration circuits. H-2 and M-2 represent concentrates of artificial hematite and artificial magnetite produced by roasting iron sulphides under different atmospheric conditions. H-1 represents a flotation concentrate of specular hematite. Each of these ores possessed peculiar properties, and as such responded differently toward agglomeration by pelletizing.

Table II. Crushing Strength of 20 Randomly Selected Pellets Expressed with Probable Error of Average Value

	Pellets fired at 1300°C														
	H-1				H-2					M-1			M-2		M-3
Additives, Lb Per Ton	10 b 50 ls	10 b 50 ls	10 b	10 b	10 b	10 b	10 b 10 c	10 b 40 c	10 b 30 c	10 b	10 b	10 b	10 b 10 bx	10 b	10 b
Conc. Condition		MR	RG			RG		Surface			RG	50 Pct RG			
1	1180	1460	730	670	1250	900	900	600	680	1250	600	650	900	630	790
2	1200	1020	620	630	1550	720	620	1000	580	3000	400	540	500	450	610
3	2500	3000	720	570	1250	750	570	1000	410	1750	600	490	450	830	870
4	1000	870	460	640	1250	550	800	900	570	940	300	620	1000	740	2500
5	1500	840	500	540	1250	480	1030	860	570	1250	300	680	400	520	610
6	3250	860	570	440	900	3000	1050	730	380	1250	550	600	1500	820	460
7	3750	1100	840	500	1250	560	950	500	160	1250	530	900	800	540	700
8	2250	2250	900	520	2750	800	2400	1000	500	1160	620	650	500	1000	670
9	880	1100	520	600	1050	840	640	910	530	1500	1100	440	1000	740	1100
10	1000	2860	650	430	670	760	950	550	600	1090	300	350	900	730	840
11	2500	1100	1070	540	980	4250	1060	540	720	1250	600	650	700	550	910
12	2000	1500	770	720	1110	910	890	600	700	3000	1100	620	800	550	680
13	1200	2500	820	620	620	630	820	1100	540	1250	300	530	600	420	880
14	2500	2300	1000	520	1050	800	1900	700	400	1250	680	1900	1000	790	840
15	2000	3840	900	580	1250	940	2000	900	330	1110	520	600	2500	720	660
16	2000	1020	1200	460	1250	660	950	1000	500	1500	3100	790	800	240	1060
17	1250	2250	850	630	940	410	1030	640	590	1500	400	730	1100	540	850
18	800	1100	840	760	2000	700	550	720	900	950	500	530	1200	800	820
19	1200	930	680	530	870	830	910	780	360	1500	2400	780	1000	930	860
20	1500	1100	600	550	1250	700	900	640	550	1250	400	730	900	540	930
Average — M	1773	1650	769	572	1224	1009	946	780	528	1450	765	689	927	653	882
Probable dev. — Q	±129	±138	±30	±13	±54	±99	±54	±30	±23	±68	±88	±32	±53	±29	±38
Best value	1800	1700	770	570	1220	1000	950	780	530	1450	760	690	930	650	880
Probable dev., pct	±7.2	±8.4	±3.9	±2.3	±4.4	±9.9	±5.7	±3.8	±4.3	±4.7	±11.6	±4.6	±5.7	±4.5	±4.3

The additives were added in pounds per ton of ore.
b denotes bentonite clay.
c denotes pulverized anthracite coal.
MR denotes a magnetically roasted conc.
ls denotes pulverized limestone.
bx denotes borax.
RG denotes a reground concentrate.

Table III. Summary of Pellets Test Results

	H-1				H-2					M-1			M-2		M-3
Additives, Lb Per Ton	10 b 50 ls	10 b 50 ls	10 b	10 b	10 b	10 b	10 b 40 c	10 b 10 c	10 b 30 c	10 b	10 b RG	10 b 50 Pct RG	10 b 10 bx	10 b	10 b
Conc. Condition		MR	RG			RG	Surface								
Avg Pellet, Diam, In.	1.132	1.050	1.165	1.180	0.998	1.015	1.015	1.035	1.020	1.125	1.052	1.042	0.975	0.975	1.042
	Screen Analysis of Pellets after 3-33-1/3' Drop Tests — Pct Weight Retained														
Mesh															
1	52.3	20.2	8.0	2.9	0.0	0.0	0.0	5.7	0.0	18.0	0.0	0.0	0.0	0.0	0.0
¾	20.6	34.6	22.8	22.2	33.6	20.3	37.7	46.3	29.4	35.9	0.0	5.7	20.8	33.1	9.7
½	15.7	22.4	27.7	42.6	19.2	24.3	15.1	8.9	27.3	9.2	21.0	27.0	24.3	13.5	27.2
⅜	3.4	12.8	13.8	10.6	22.8	25.0	19.7	11.2	14.3	14.3	41.5	33.9	21.0	17.6	33.3
3	2.5	4.2	10.6	6.6	10.8	14.0	10.1	12.5	11.7	8.6	18.0	17.3	14.8	13.0	13.3
4	0.9	1.6	3.6	2.8	4.8	7.1	6.0	3.7	4.1	4.1	8.8	6.6	4.6	7.3	5.5
6	0.6	0.9	3.3	2.2	2.4	3.3	3.2	2.7	2.6	2.1	3.5	3.2	3.6	3.9	2.5
8	0.3	0.4	1.4	0.9	0.9	1.8	1.8	1.5	1.6	1.1	2.0	1.5	2.3	2.0	1.6
10	0.2	0.4	1.4	0.6	0.8	1.3	1.2	0.9	1.1	0.7	1.5	1.1	1.6	1.7	1.0
14	0.2	0.3	1.0	0.7	0.6	0.9	1.0	0.6	0.8	0.7	1.0	0.8	1.1	1.3	0.8
20	0.1	0.3	0.7	0.6	0.4	0.6	0.7	0.4	0.6	0.6	0.6	0.5	0.7	0.9	0.5
28	0.1	0.2	0.6	0.5	0.2	0.4	0.6	0.3	0.5	0.4	0.5	0.4	0.5	0.7	0.4
−28	3.1	1.7	5.1	6.8	3.4	1.0	2.9	5.3	6.0	4.3	1.6	2.0	4.7	5.0	4.2
Avg diam after drop, in.	0.675	0.555	0.355	0.325	0.381	0.359	0.386	0.390	0.336	0.441	0.283	0.321	0.313	0.316	0.314
Pct original size	59.4	52.8	30.5	27.5	38.2	35.3	36.2	34.8	33.0	39.2	27.4	30.7	32.1	32.4	30.1
Pct −10 mesh from drop	3.5	2.5	7.4	8.6	4.6	2.9	5.2	6.9	7.9	6.0	3.7	3.7	7.0	7.9	5.9
Crush test load, lb	1800	1600	750	550	1200	1000	780	950	550	1450	750	700	900	650	900
Abrasion test, pct −65 mesh	1.2	1.7	0.9	4.0	0.5	0.6	2.5	0.7	1.3	1.8	0.4	0.9	1.2	2.1	1.1
Pellets per 1000 g, no.	27	34	25	24	35	33	33	31	32	24	29	30	36	36	29
Pellets, wt, g	37.0	29.4	40.0	41.6	28.5	30.3	30.3	32.3	31.3	41.7	34.5	33.3	27.8	27.8	34.5
Pellets, volume, cc	12.5	9.9	13.5	14.1	8.4	8.9	8.9	9.5	9.2	12.2	10.1	9.7	8.1	8.1	9.8
Density of pellet gm/cc	2.97				3.36					3.42			3.44		3.52
S.G. of ore gm/cc	4.23				4.86					4.44			4.40		4.43
Porosity of pellet, pct	29.6				30.9					23.1			21.9		20.6

Prior to balling, the ore concentrates were blended in the dry state with ½ pct by weight of bentonite and, in certain instances, with various quantities of other pulverized additives. These blends were further mixed with about 10 pct water and each mixture used as the laboratory balling drum feed. The balls were carefully formed by the method described by Tigerschiold and Ilmoni,[1] to produce −1⅛ +1 in. spherical compacts. These were fired from the wet stage to the fired stage in the manner outlined in the laboratory pellet firing procedure. The fired pellets were tested in the manner outlined in the pellet-testing procedures.

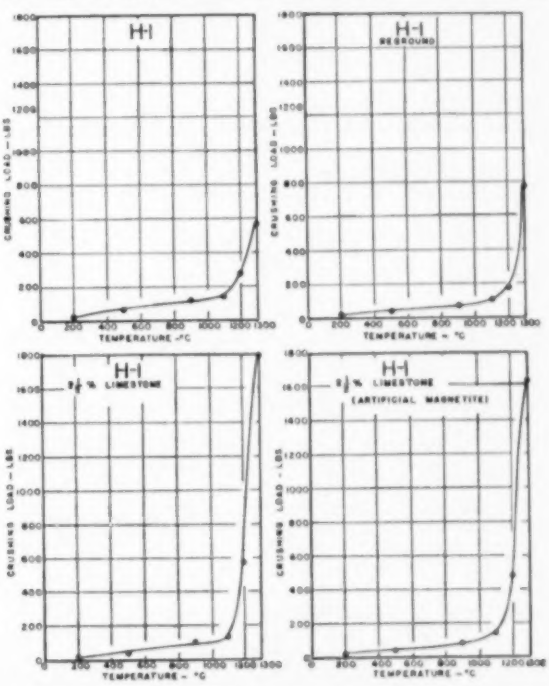
A swelling variety of bentonite was added as a pelletizing aid to all the iron ore concentrates. By

Table IV. Chemical and Screen Analyses of Iron Ore Concentrates Used for Pelletizing Tests

Concentrate Constituent	H-1, Pct	H-2, Pct	M-1, Pct	M-2, Pct	M-3, Pct
Fe	61.90	66.45	60.35	67.20	67.70
SiO_2	7.32	2.51	8.98	3.54	4.57
Al_2O_3	1.93	0.82	4.42	1.13	0.23
CaO	0.27	0.29	0.30	0.45	0.32
MgO	0.51	0.27	0.29	0.50	0.41
Mn	0.18	0.10	0.25	0.28	0.27
P	0.074	0.005	0.033	0.016	0.010
S	0.055	0.209	0.357	0.113	0.009
Mesh Size			Screen Analysis		
65	0.7	0.5	4.1	0.2	1.1
100	3.4	0.7	6.7	0.3	0.3
150	8.9	1.3	12.0	0.6	1.3
200	14.3	5.2	11.5	1.8	3.4
325	15.2	12.8	10.2	10.1	8.8
400	21.0	18.6	12.8	16.8	23.5
800	21.1	37.8	18.5	38.2	26.9
1600	10.1	13.4	12.8	17.8	18.0
−1600	5.3	9.7	11.4	14.2	16.7
−325	57.5	79.5	55.5	87.0	85.1
−325 mesh after regrind	87.4	92.0	78.0		

virtue of particle size and crystal chemistry, montmorillonite clays, or bentonites, aid the balling phenomenon, the green strength, the dry strength, and in some instances the fired strength. The coherency imparted to green pellets by bentonite materially reduces spalling and dusting of pellets during the drying stage of firing, and the high alumina content of bentonite aids the ceramic bond formation.

The knowledge of these benefits, coupled with the low cost of the reagent, has made bentonite usage attractive to the pelletizing process. For these reasons, bentonite was added to all the ores used for the standardized tests. Ten pounds of bentonite were added to each ton of ore concentrate. To aid ceramic bond formation within the fired pellets, pulverized limestone and borax were added to ores difficult to pelletize. Limestone, after coincidental calcination during firing, provided active CaO which reacted at



Figs. 9 to 12—Strength temperature relationships of iron ore pellets.

Table. V. Strength-Temperature Relationships of Laboratory Fired Iron Ore Pellets

	H-1				H-2		M-1		M-2		M-3
Additives, Lb Per Ton	10 b 50 ls	10 b 50 ls	10 b	10 b	10 b	10 b	10 b	10 b	10 b 10 bx	10 b	10 b
Concentrate Condition		MR	RG			RG		RG			
Firing Temperature	Crushing Strength, Lb										
200°C	20	20	20	20	10	10	20	20	10	10	20
500	30	30	40	60	30	30	130	180	60	20	130
900	120	90	100	110	50	100	180	370	160	50	280
1100	130	140	110	140	240	230	460	640	200	70	470
1200	580	470	190	270	650	780	670	700	330	270	680
1300	1800	1620	770	570	1220	1000	1450	760	930	650	880

high temperatures with Fe_2O_3 and SiO_2 to form readily fusible calcium ferrite and solid solutions of CaO, SiO_2, and Fe_2O_3. Borax functioned as a low temperature fluxing agent and probably aided the grain growth mechanism by a solution-precipitation phenomenon.[11] The pronounced beneficial effect of these additives is shown in Table III. H-1 pellets containing 2½ pct limestone and M-2 pellets containing ½ pct borax had remarkable strength properties in contrast to properties of the respective pellets without these additives.

The effects of firing temperatures on the crushing strengths of various kinds of pellets are given in Table V and are graphically portrayed in Figs. 5 to 12. It was observed that pellets of natural magnetite ore, such as M-1 and M-3 of Figs. 7 and 8, increased in strength with increasing temperatures, and at 500°C the pellets had crushing strengths of about 150 lb. These phenomena were not observed with pellets of artificial magnetite, such as M-2 and converted H-1 of Figs. 6 and 12, and were not observed with hematite pellets of H-1 and H-2 of Figs. 5 and 9. The low temperature cementation of natural magnetites has been discussed by Cooke and Ban.[8] It was not known why this same phenomenon did not occur with pellets of artificial magnetite. Zetterstrom[12] has shown that artificial magnetite oxidizes at much lower temperatures than natural magnetite and perhaps this rapid oxidizing nature of artificial magnetite inhibits cementation at these temperatures. In that low temperature cementation was coincidental with the exothermic phase change of natural magnetite to hematite, it was understandable that hematite pellets did not cement at low temperatures.

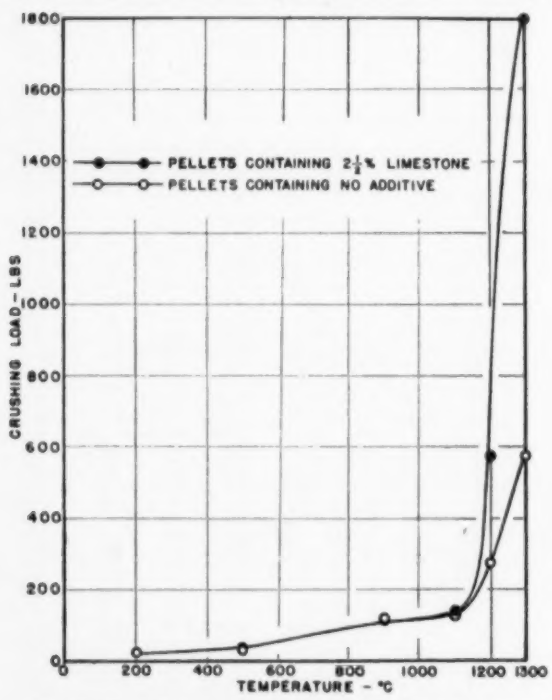


Fig. 13—Strength-temperature relationships of H-1 iron ore pellets showing the effect of pulverized limestone as an additive.

The strength-temperature curves of Figs. 5-12 give an indication of how the different kinds of iron ore pellets can withstand temperature gradients within a shaft furnace. If an arbitrary crushing strength of 400 lb is established for the minimum strength of acceptable pellets, it can be seen that the respective ores will withstand the following temperature differentials from 1300°C: M-3, 250°C; M-1, 225°C; H-2, 150°C; H-1 and M-2, 50°C. Pellet additives change these tolerable temperature differentials. For instance, 2½ pct limestone in the H-1 pellets increases the temperature differential from 50° to 125°C, and ½ pct borax in the M-2 pellets increases the temperature differential from 50° to 100°C. Three primary characteristics of the strength-temperature curves denote the relative response of the concentrates toward pelletization. These are as follows: the maximum strength that can be acquired, the extent of the low temperature strength increase, and the tolerable temperature gradient. These three factors are roughly composited in a diagrammatic sense by the area directly under the strength-temperature curves bounded by the 0-lb strength ordinate and the 1300°C temperature ordinate, see Figs. 13 and 14. With this notation it appeared that a classification of ores could be made in order of response toward pelletization. These would be as follows for the five ores studied: M-1, M-3, H-1 plus 2½ pct limestone, H-2, M-2 plus ½ pct borax, H-1, and M-2. This classification does not include the factors of abrasion and impact resistance or the important technical differences of shaft furnace pelletization of hematite and magnetite mentioned previously.

Table III summarizes the physical properties of pellets fired in the laboratory apparatus to an ultimate temperature of 1300°C. This table shows the effect of additives such as limestone and borax and the effect of the condition of the concentrates, such as that of reground or magnetically converted concentrates. The physical properties included are as follows: 1—pellet sizes, 2—pellet weights, 3—screen analyses of pellets after the drop test, 4—values of the crush, drop, and abrasion tests, and 5—the apparent density of the pellets. The determination of the apparent densities was made by use of an improvised widemouthed pynonometer.

The effect of regrinding concentrates prior to pelletizing appeared to be of small consequence. Reground ores of H-1, H-2, and M-1 produced pellets with greater abrasion resistance, and in the case of H-1 only slightly greater crushing and impact resistance. Reground ores of M-1 and H-2 yielded pel-

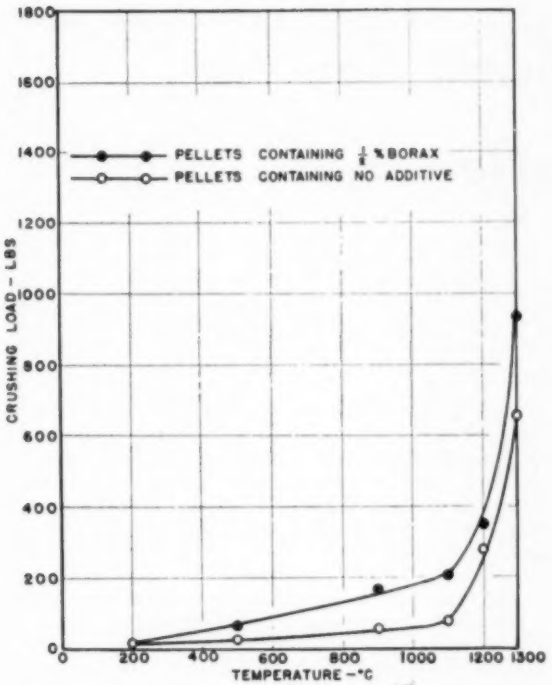


Fig. 14—Strength-temperature relationships of M-2 iron ore pellets showing the effect of pulverized borax as an additive.

lets with lower impact and crushing resistance. These two reground ores, M-1 and H-2, showed great tendency to spall while being fired, that is, the ore compacted too tightly in the wet stage, and the expulsion of balling water was inhibited during the firing process. Approximately 21 pct of the pellets composed of reground M-1, 9 pct composed of reground H-2, and 5.2 pct composed of 50 pct reground minus 50 pct original M-1 spalled during the drying stage of the firing process. No spalling occurred during the firing tests of all other pellets.

The beneficial effect of 2½ pct limestone in H-1 pellets and the less remarkable beneficial effect of borax within M-2 pellets are shown by the strength properties given in Table III. Visual examination of the cracked fragments of these pellets denoted conchoidal glassy fractures which exemplified the bonding action from the additives, especially so when contrasted to the rough crystalline fractures of the same pellets containing no additives.

The apparent detrimental effect of internal carbonaceous matter in iron ore pellets was evident from the decreasing strength properties of H-2 pellets containing increasing quantities of internal coal. Pellets containing 2 pct coal on the exterior, however, appeared to have greater strength properties than pellets containing lesser amounts of coal internally. This demonstration indicated that within pellets containing internal coal, gaseous diffusion lagged behind heat transfer, and carbon abstracted oxygen from the ore rather than from the hot gases. This reaction caused direct reduction of the iron ore and consequent defects in the pellet structure, such as hollow cores or contracted, sintered volumes from the phase changes at the very high pelletizing temperature. The reduced products reoxidized in some instances to the higher oxide states of iron, but left evidence of past history as a poor pellet structure with a low materials strength.

Provisions were made for better gas-solid reactions during the pelletizing tests by the application of coal to the pellet exterior. This naturally prevented disruption of the pellet interior, and served as a practical means of conveying fuel into the pelletizing zone of the laboratory apparatus.

Pellets comprised of H-1 converted to artificial magnetite and mixed with 2½ pct limestone were comparable in all strength properties to pellets of unconverted H-1 ore containing the same quantity of limestone. From this conversion some of the chemical advantages of magnetite were obtained without detriment to the pelletizing process. The commercial production costs of pelletizing hematite will unquestionably be greater than that of pelletizing magnetite because of the intrinsic source of thermal energy within magnetite. This cost difference, if appreciable, could dictate the necessity of beneficiating some fine-grained hematite ores by the magnetic roasting process.

Summary

This paper describes the design and operation of a laboratory apparatus for pelletizing iron ore by simultation of shaft furnace firing conditions. Strength-temperature relationships were determined for five different kinds of iron ore concentrates representing products from various regions planning to beneficiate iron ore by agglomeration. In addition to these relationships, the effects of various chemical additives and various methods of concentrate preparation were investigated. All the investigations were discussed with reference to the crushing, abrasion, and impact resistance of the pelletized products.

Acknowledgement

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Mine Drainage at Eureka Corp. Ltd., Eureka, Nev.

by George W. Mitchell

THE property of Eureka Corp. Ltd. is located in the approximate geographic center of Nevada, 2 miles from Eureka, the county seat. The great sources of power, the Colorado, Snake, and Salmon Rivers and the rivers of northern California, are 300 to 500 miles distant, and no lines serve areas closer than 150 miles. Fuel for diesel and steam generation is available in Utah, 300 to 400 miles to the east. Eureka's railhead is 80 miles north where two trunk lines cross the county. A spur line serves Ely, 77 miles east. Good highways connect Eureka to the railheads.

Activity in the Eureka mining district began in the early 1870's. The oxidized high grade lead-silver-gold ore terminated against the footwall of the Ruby Hill fault, and in 1890 the main operations ceased. In 1938 Eureka Corp. Ltd. discovered ore in the hanging wall of the fault by diamond drilling.

The history of Eureka in the late 1800's indicates that there was some water at 600 to 800 ft in the old workings, probably accumulations above the water table which did not seriously interfere with mining operations. Both the Locan and Richmond shafts were sunk to a level below the table, but apparently the only serious difficulty with water occurred in the Locan. The steam pump used when the last work was done on the 1200 level in 1923, many years after exhaustion of the main orebodies, is still installed on the Locan 900 level. The capacity was about 500 gpm, lifting 750 ft to the 100 level, which connected with the surface. In addition to this, bailers were used to keep the 1200 level free of water. It is said that pumping in 1923 lowered the water in the Holly shaft, about a mile and a half away, but this seems doubtful. The pumping was of short duration because no ore was found.

When work at the new Fad shaft was started in 1941 Eureka Corp. Ltd. engineers were fully aware of the probability of encountering water in large volume. Their primary exploration and development had to be carried on at the 2250 level.

The first water was encountered at 300 ft. This was undoubtedly surface drainage in the bedding of the Pogonip limestone and was less than 100 gpm. The fractured, loose Hamburg dolomite at the water table was not well cemented, and relatively little water, 300 gpm, percolated through it with difficulty. At 1350 ft well-cemented dolomite containing some open fractures was encountered. These fractures produced the first water of consequence, 750 gpm. At 1700 ft the volume was 1000 gpm increasing to the maximum during shaft sinking, 1600 gpm, at the 2000 level. Secret Canyon shale, a dry formation, was entered at 2100 ft, where a concrete water ring was placed to catch all of the water. The volume decreased rapidly to a constant flow of 1200 gpm. Below 2100 ft the shaft and stations remained in the shale and water was not a problem.

Several faults of moderate displacement, including the reverse Martin fault, had been intersected during the traversing of 1000 ft of wet Hamburg, but no undue quantities of water were encountered. Observations in the diamond drill holes in the ore zone area showed a rapid lowering of the water table.

The shaft was flooded when it left the dry shale and entered the water-bearing Eldorado dolomite on the 2250 level, crossing a fissure which paralleled the Martin fault. High pressure water doubled the volume then being pumped. Pipe failure through a water door bulkhead was a contributing factor.

Immediately following this flooding in March 1948 preparations were made to recover the shaft as rapidly as possible by increasing power and pump capacities as needed. Measurements before flooding indicated the water could be lowered at a fast rate. However, the water table did not recede as rapidly as expected and volumes required to lower the water in the shaft were higher. Obviously the size of the main water channel on the 2250 level was increasing because of erosion, allowing greater volumes to enter the workings and draining beyond the cone originally being drained during shaft sinking. Eroded material was being deposited in the shaft below the 2250 level in serious proportions. In December 1948 a second flooding of the Fad shaft was allowed for the purpose of reassessing existing conditions and studying alternate methods of attack.

The detailed geology of the Eureka mining district, see Fig. 1, has been described during the past 75 years by many geologists.[1] Only the general features and those which seem to affect the drainage problem will be discussed.

The old ore zone, mined between 1870 and 1890, is located in a wedge-shaped block of Eldorado dolomite between the footwall of the Ruby Hill fault and the underlying Prospect Mountain quartzite, see Fig. 2. Production of high grade oxidized lead ore containing high values in gold and silver has been variously estimated at $50 to $90 million. The tonnage mined was probably close to 1,500,000, nearly all of which was found above the water table.

The new ore, discovered by diamond drilling in the hanging wall of the Ruby Hill fault, is a flat-

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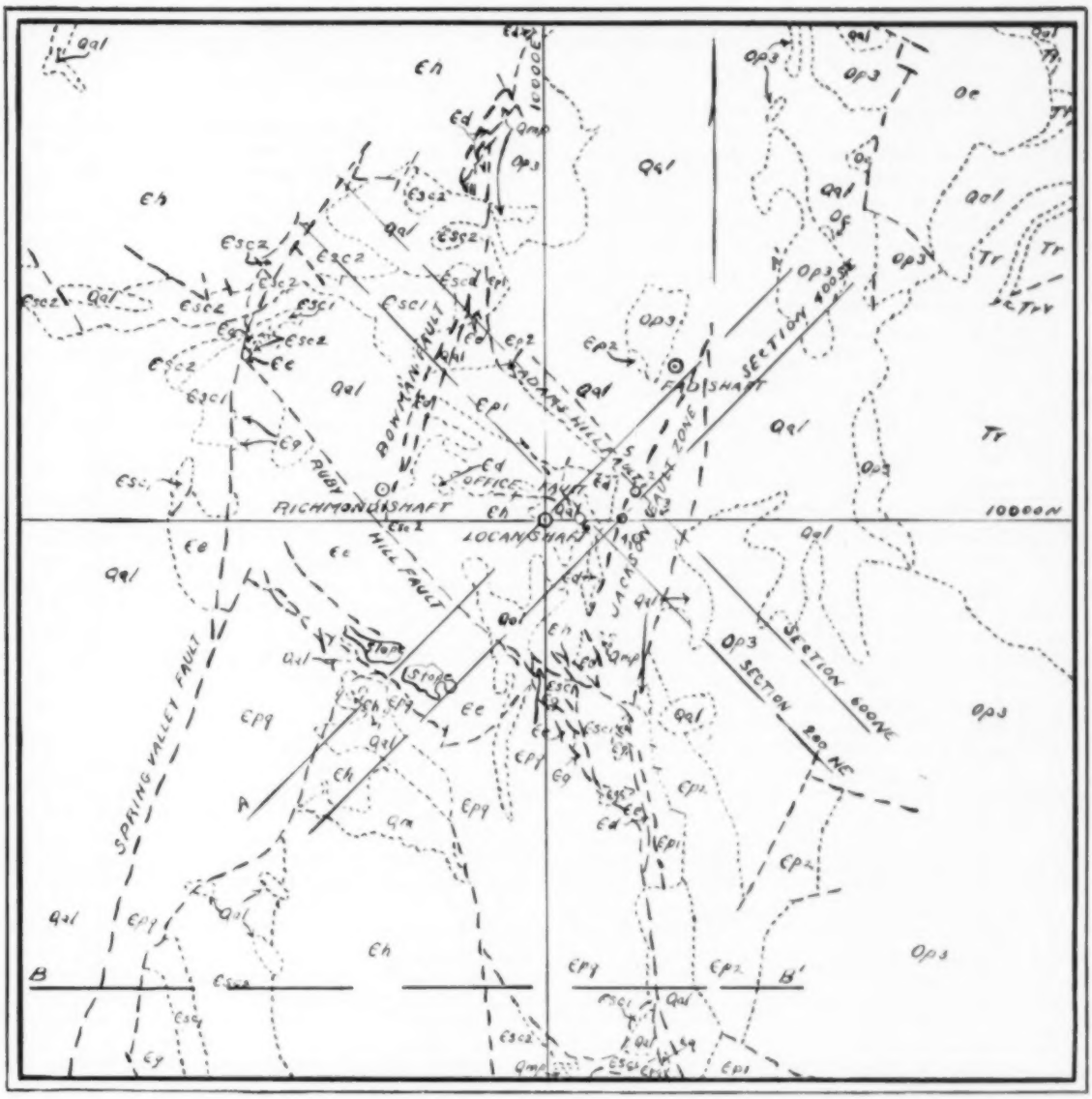

Fig. 1—Surface geology of Eureka mining district.

epg	—	Prospect Mountain quartzite
Ee	—	Eldorado dolomite
Eg	—	Geddes limestone
Esc1	—	Secret Canyon shale
Esc2	—	Secret Canyon shale
Eh	—	Hamburg dolomite
Ed	—	Dunderberg shale
Ep1	—	(Lower)
Ep2	—	(Middle) Pogonip limestone
Op3	—	(Upper)
Oe	—	Eureka quartzite
Qal	—	Alluvium
Qm	—	Quartz monzonite
Qmp	—	Quartz monzonite porphyry
Tai	—	Andesite (intrusive)
Tae	—	Andesite (extrusive)
Tr	—	Rhyolite
Trv	—	Rhyolite vitrophyre
Tt	—	Tuff
Tb	—	Basalt

— — — Fault
····· Contact
——— Section
Drill Hole

lying sulphide deposit of excellent grade lead and zinc with good gold and silver values.[2] Diamond drilling has indicated a limited tonnage of ore but geological conditions are such that tonnages could be large.

All of the sediments are folded and have been disturbed by thrust and normal faulting, in some cases of great magnitude. Thrust faulting from the west is a principal structural feature. It has elevated and erosion has exposed the Cambrian beds which form the Prospect range, highest point 9600 ft above sea level, overturning the beds for the 8-mile length of the core of the range. Normal faults are numerous in the main part of the range. The Jackson fault and its branches on the east flank have been traced for several miles from the south end of the Prospect range to the north slope adjacent to the Fad shaft. On the west flank of the range the Spring Valley

fault, roughly paralleling the Jackson and less than a mile away, shows much displacement and, in places, the fault zone is wide and badly brecciated. Both the Jackson and the Spring Valley with their connecting cross faults could be conduits bringing water from the south toward the areas to be drained. The Jackson is known to be filled with intrusive rhyolite in some locations, and this condition, if sufficiently continuous, could form a partial barrier.

The geological column as exposed in the Fad shaft and drill holes is shown in Table I.

Table I. Geological Column Exposed in the Fad Shaft

Strata	Era	Level
Alluvium and surface rhyolites	Recent	100
Pogonip limestone	Ordivician and Upper Cambrian	690
Dunderberg shale	Upper Cambrian	250
Hamburg dolomite	Upper Cambrian	1060
Secret Canyon shale	Middle Cambrian	315
Geddes limestone	Middle Cambrian	0 to 200
Eldorado dolomite (formation in which the ore occurs)	Middle and Lower Cambrian	800 to 1000
Prospect Mountain quartzite	Lower Cambrian	300 to 1600

The three competent formations, the Prospect Mountain quartzite, Eldorado dolomite, and Hamburg dolomite, were badly crushed in the thrusting, the dolomites often recemented loosely. The less competent formations were drag-folded and distorted but retained their bedding.

Work done in the shales shows them to be all but impervious to water. Their dip places them between the mine workings and Diamond Valley, into which pumped water flows, where the water table is less than 100 ft below the surface. The shales should form a protective barrier, which may be imperfect, however, because they are cut by a number of faults.

No work has been done below the water table in the Geddes limestone, but upper exposures indicate that water could move easily along bedding planes.

The Hamburg and Eldorado dolomites are of identical chemical and physical character. Both contain a stockwork of fissures and faults, some of which are practically open channels. Both have been observed as capable of releasing quantities of water to mine openings. Experience indicates that there are large solution voids above, at, and just below the ground water level, but it is believed that only a few occur of sufficient magnitude to cause difficulty at the ore horizon 1200 ft below. The ore is within the Eldorado, and the Hamburg lies only a short distance above. There seems no choice but to drain these formations if the orebodies are to be successfully exploited.

The Fad shaft is 8x23 ft in rock section, containing four compartments in line. No. 3 compartment contains ventilation lines, one 12-in. and two 10-in. pump columns, and other pipe lines. No. 4, the manway, contains armored electric cable. The upper section, below the 30-ft concrete collar, is timbered for 300 ft and the next 250 ft solid-lined with concrete. The remainder consists of 6x6-in. H-section steel sets. Guides are surfaced fir timber, fastened to the sets with steel brackets. All shaft and pump stations are timbered with 8x8-in. H-section steel.

Standardization of equipment and extreme flexibility govern the general arrangement for handling water in the Fad shaft. The capacity of the equipment is relatively small, a number of units being used, so that shutdowns for repairs on any single unit affect the general operation very little. Standard, well-tested equipment has been easier to obtain and cheaper in initial cost. Since replacement parts are readily available, inventory can be kept at a minimum.

To fit into these requirements, permanent pump stations, see Fig. 3, have been established at the 800 level, above the water table, see Figs. 4 and 5, at the 1700 level, and at the 2250. A temporary intermediate station was established at the 1200 because the sinker pumps could not lift the full distance from the 1700 to the 800 level.

The capacity of each shaft pump column is about 3000 gpm and friction losses are low. Standard weight pipe is used in the lifts. In the event of trouble in any one column the water may be diverted to the other columns by means of a valved manifold at the lower end. Valves are of heavier than standard design, but no extremely high head fittings are necessary.

Heavy lead-covered armored power lines direct from the power house circuit breakers to the pump stations are of sufficient capacity to operate two pumps. Meters on the power house distribution panel for each line record the demand, kilowatt-hour consumption, and operating time of two station pumps. Sinker and the submersible-type pumps also have their own panels. Underground transformers are necessary only to transform the power for the sinker pumps and auxiliary mine equipment, all other large motors being of the same voltage as the power generated.

The first three generating units were of 300-kw capacity. Three heavy-duty units of 1000-kw (1250-kva) capacity, generating 3-phase 60-cycle 2400-v power have been added, see Fig. 7. During the period in 1948 when recovery operations were in progress, after the first flooding of the shaft, four readily available lighter duty units of similar capacity were obtained. At the present time, August 1952, the 300-kw machines, because of size, have been taken out of service. Two more heavy duty units are ready for delivery. Any one of the large units may be shut down for extended periods without affecting progress. Two may be taken from the line for shorter periods without serious consequences.

A 600-hp double-drum hoist has been selected for the two hoisting compartments, while a small 50-hp single-drum hoist operates in No. 3 compartment. Three small compressors furnish adequate compressed air and a well equipped shop supplies construction and repair facilities.[3]

The submersible deep well pumps used are very well adapted for use in the shaft because of the small horizontal size of both the motor and pump, designed for 20-in. well casing. Three of the submersibles are driven by 450-hp, 3-phase, 60-cycle, 2400-v motors while the fourth has a 350-hp motor. The pumps are of 13 stages. The rated capacity of each of the three is 1600 gpm against 1000 ft, while the fourth is 1250 gpm, although all will pump greater volumes under lower heads. Two more 350-hp, 5-stage submersibles rated 2000 gpm against a 600-ft head are available. A higher head pump may be connected to these motors when needed. Each of the first four is hung on a 10-in. standard pump column from a location just above the water table, 1025 ft below the shaft collar on special steel supports. The approximate weight of each pump, column, and water within is 25 tons. Special long thread screwed joints are used on the upper end of

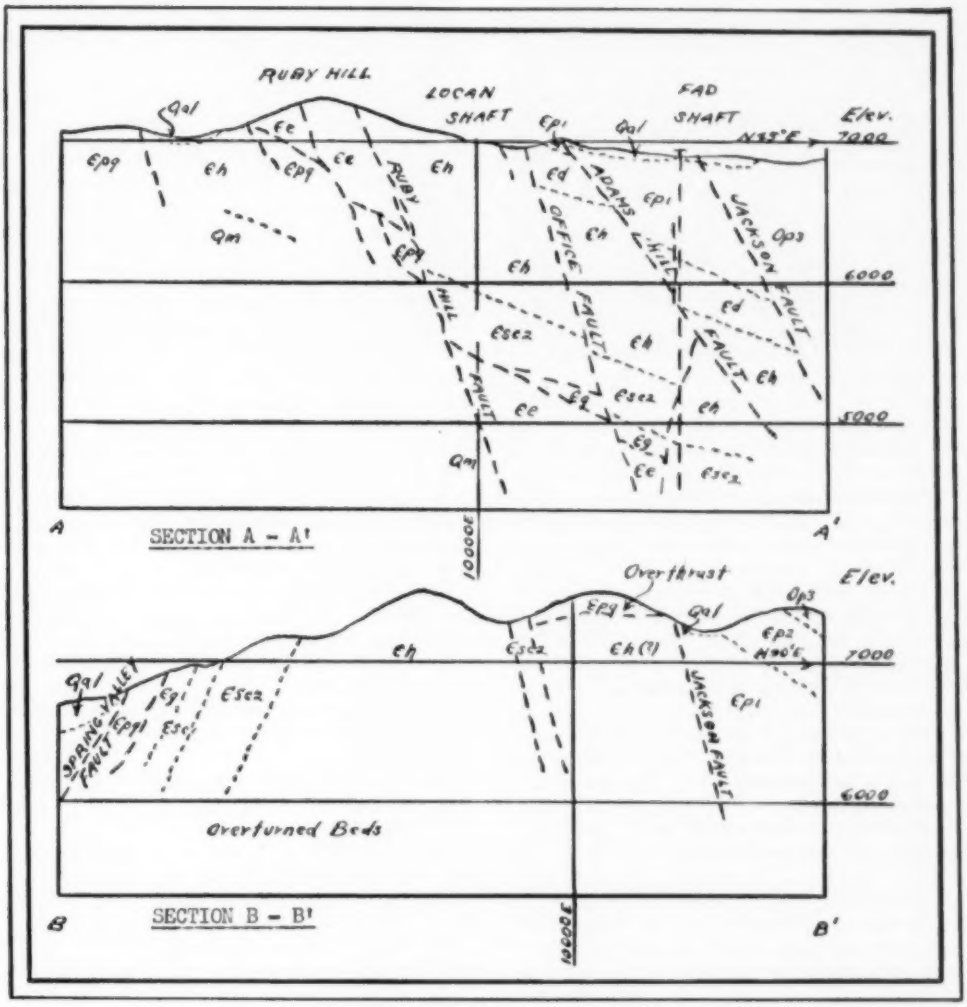

Fig. 2—Old and new ore zones of Eureka mining district.

the column. The pump and column is assembled and placed by use of a special sheave block arrangement using the shaft hoist as motive power. Two of the pumps are in No. 2 hoisting compartment and two in No. 3. No. 1 compartment is kept clear for the movement of men and supplies and No. 2 may be used for these purposes above the pump support.

Station pumps are all of the 3550-rpm, two-stage, horizontal type. On the 800-level pump station they are equipped with 350-hp, 2400-v motors, each delivering 1000 gpm of water to the surface. From the 1700 level to the 800 they are equipped with an impeller of slightly larger diameter and a 450-hp motor. Each pump has a capacity of 1200 gpm. From the 2250 level to the 1700 the impeller size is the smallest and the driver is a 250-hp motor. The horizontal-type station pump on the 2250 level will be replaced with submersible pumps and motors when the level is recovered, so that possible flash floods in the future may not cause loss of the station. Ten station pumps, installed on the two upper stations, were sufficient in late 1948 to pump 9000 gpm leaving two spares on the 1700 and one on the 800. Replacement of rotating elements, when necessary, was easily and rapidly accomplished.

All station pumps are automatically controlled by an electronic device developed in 1947.[6] The probes are placed in the sump in such a manner that the water level in the sump makes and breaks contact with them. Each pump in succession comes into operation, if the water in the sump continues to rise, until a sufficient number are operating to cause it to recede. The last pump to come into operation cuts on and off automatically, keeping the sump at a predetermined level. Thus, only the number of pumps necessary to maintain a constant sump level are operated and, if the supply of water to the sump is cut off, all pumps will successively and automatically be shut down. The rare failure of the electronic device on any one pump, usually because of a burned-out tube, does not affect the other pumps. It merely keeps the pump out of operation until repairs are made. An alarm installed in the power house panel reveals such failures immediately and no full time attendant is necessary at any of the stations. The panel records are checked daily, particularly for a dropping off in the demand of each pump motor. This is a good indicator of pump impeller ring and interstage bushing wear. The pump inspector is equipped with a clampon ampmeter so

he may test each motor for demand as station inspections are made.

All sumps are at a higher elevation than the pump stations so that all station pumps may have a positive suction head. No difficulty has been experienced in keeping the pumps primed, but a precaution against dry pumps has been provided. If the discharge of any pump fails to come up to a predetermined pressure in a few seconds after starting, it is automatically shut down by a pressure governor installed in the starter and an alarm is sounded in the power house panel. Additionally if, during operation, the pressure is reduced because of a broken pipe line or other similar cause, the pump is shut down by the pressure governor.

Station pump wear has been low for two reasons. First, the sediment in the water, when there is any, is non-abrasive. All of it has been limestone, dolomite, and shale particles containing little or no quartz or other hard material. The fine material is quite difficult to settle. Second, the coarser gritty particles are settled out in settling ponds at the sump discharge end or in the sumps themselves. The settling ponds designed into each sump have proved too small to remove effectively a large amount of coarse solids and keep the main sump free of them. Erosion in the 2250 level water channel in 1948 produced an excessive amount of solids which built up in both the settling ponds and the sumps. However, in normal operation it is believed that the greater part of the coarse solids will be settled out in the ponds and easily removed.

The water is slightly alkaline, and though it is hard, no lime has been deposited in the pipe lines or pumps. Corrosion is not likely to be a serious problem, even after the sulphide orebodies are being mined, because of the neutralizing effect of the dolomite rocks.

The heat generated by the large motors in the pump stations has been a problem and will remain so until a second opening providing adequate ventilation has been made. It is not economically feasible to blow sufficient air to the stations, although two 18-in. steel ventilation lines are in the shaft. However, the 60° water provides a cool medium for heat exchange. Two large radiators which circulate mine water and are equipped with large propeller-type fans have been placed on the 1700 level pump station. They absorb sufficient heat to maintain proper station temperature.

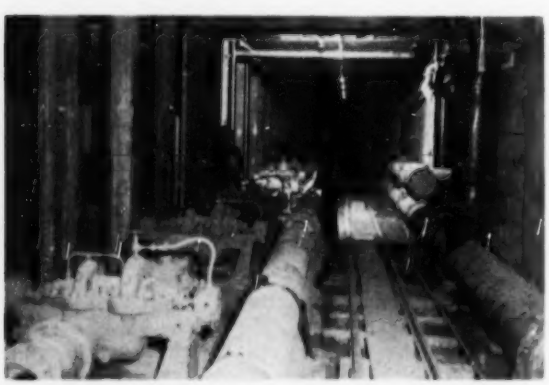

Fig. 3—No. 2 section, 800 level pump station, pump side. At right is the 1700 level pump discharge line and the 800 level suction lines. At center is the 800 level discharge line. Motors and starters are at left of center posts.

Many engineers whose advice has been sought suspect that the water course, intersected on the 2250 level, may be one of a few carrying large quantities which might be grouted, frozen, or otherwise blocked. Although this water course can be grouted, however, it seems certain that many similar channels, duplicating the condition now existing, will be cut in developing the ore zone. The quick response of the water level, as measured in the diamond drill holes, to any change of level in the Fad shaft indicates a close hydraulic connection between the two areas, although they are 1200 ft apart. Blocking off one channel will merely cause the water to find a new way into the workings, but it seems likely that grouting in localized areas will be used. Most engineers, including those of the U. S. Geological Survey Ground Water Division, believe that a typical ground water problem is presented. Below the ground water level porous rock with interconnecting movement, bedding, and jointing planes are saturated with water. The same rocks are the host rocks of the ore. The expense of lowering the water table in the vicinity of the workings to a safe horizon will be great, but this appears to be the only solution to the problem.

The general topography immediately suggests the possibility of a drainage tunnel. Although the shaft collar is approximately 7000 ft above sea level, all the valleys within a radius of 50 miles are about 6000 ft. No tunnel of reasonable length could tap the water table in the vicinity of the ore zone, but some 700 to 800 ft of head could be removed from the total lift by a tunnel about 2 miles in length. Ultimately the economics of such a tunnel will be worked out, but at the present time such a project does not seem feasible.

The reduction in the horse power required to lift water and friction losses in pump columns and electrical and pump efficiencies has received much thought. Air and gas lifts have been considered, by themselves and in combination with conventional pumps. While there are possibilities of large savings in power through increased efficiency, the engineer is always faced with the fact that the energy necessary to lift a given weight of water a given distance is constant.

The plan to unwater consists of five phases: 1—draw down and recovery tests, 2—pumping from the Fad shaft with recovery of the 1700 level as the first objective, 3—development of additional water to bring the total volume to 12,000 gpm, 4—continued pumping to lower the water table to a safe horizon, and 5—recovery of the 2000 and 2250 levels, to be advanced to the ore zone and development of the ore.

The draw down test will require about a month. The volume pumped during the draw down will be 3600 gpm, the capacity under an 800-ft head of two of the three 450-hp submersible pumps. One of the 450-hp submersibles will be a standby so a constant volume can be maintained, the allowable maximum variation being 3 pct. The volume will be controlled by an orifice volume measuring device and throttling valves in the submersible pump discharge line, all of which will be located on the 800-level station. The volume pumped from the shaft will be delivered to the 800-level sump and four station pumps will lift to the surface. Three of the station pumps will operate continuously and the fourth intermittently to handle the 3600 gpm. Stand-by station pumps are provided.

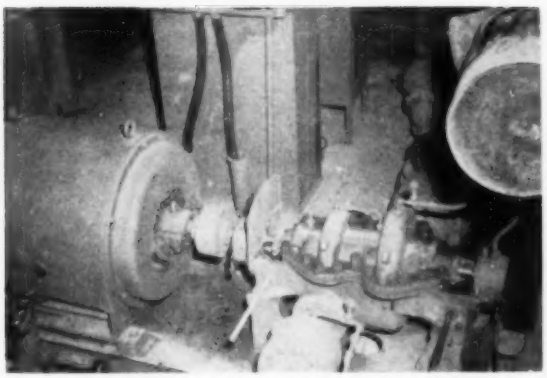

Fig. 4—No. 1 pump unit, 350-hp, in No. 1 section, 800 level pump station.

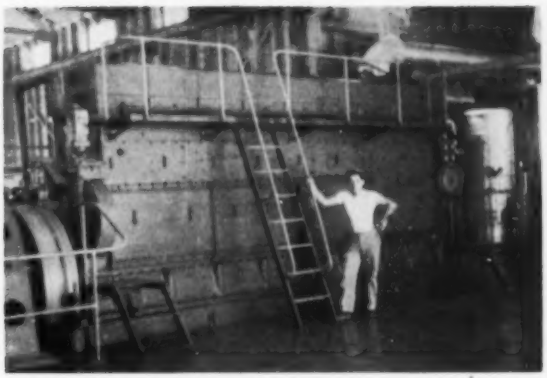

Fig. 5—Power unit No. 1, 1000 kw.

Installed in the main discharge line on the surface is a Parshall flume, of 14,000-gpm capacity, equipped with a recording volume meter. After being measured the water will be discharged through 5700 ft of 24-in. steel pipe to an open ditch. Another Parshall flume of the same dimensions as the first is to be installed in the stream 2½ miles from the shaft to check the volume for return circulation to the mine. Plans are to check the volume again at a point 4 miles from the shaft if no recirculation is observed closer.

Recording devices at the diamond drill holes and the Holly shaft will observe the ground water level as it recedes.

Approximately 175,000,000 gal will be pumped during the test. It is expected that this volume will lower the water in the shaft about 450 ft, in the diamond drill holes 250 ft and in the Holly shaft, 1¼ miles distant, 1 or 2 ft. The shape of the curve of draw down, irregularities in flattening or steepening, will indicate any additional water from lines of recharge or the existence of good barriers. It is expected that the most economical time-volume figures may be calculated from these observations.

If it appears necessary, these figures will be checked by allowing the water to recharge for a period equal to, or possibly shorter than, the draw down. A good estimate can then be made of the recharge to the basin formed after the water table has been lowered to the mining horizon.

The initial pumping rate following completion of the draw down test is expected to be approximately 6000 gpm. This or a slightly lesser or greater volume will be maintained, depending upon the volume which may be taken without again causing erosion in the 2250 level channel. At this volume it is expected that the 1600 horizon will be reached rapidly and that a month or two of steady pumping will lower the water to the 1700 level. The head capacity of the four submersible pumps is sufficient to lift 6000 gpm from a point below 1700 to 800 level.

The contact between the overlying Hamburg dolomite and the Secret Canyon shale cuts through the 1700 shaft station, see vertical section. The dry shale extends approximately 600 ft to the south. A crosscut will be extended in this direction to a point near the bottom of the shale close to the underlying Geddes contact. With the protection of a water door in the crosscut and valved collar pipe, drill holes will be extended ahead of and below the face into the water-bearing Geddes and/or Eldorado. In this manner it is expected that additional water can be made, bringing the total volume pumped to approximately 12,000 gpm.

The objective is to increase volume to shorten time. Pumping from the Fad shaft and this area will draw down the water table above the ore zone, forming a trough-like basin in the location of the projected 2000 and 2250 levels crosscuts.

As the water table recedes and the drill holes begin to produce less water, the 1700 crosscut will be extended into the Geddes and Eldorado formations to maintain the volume. When practicable a winze above the ore zone will be sunk and possibly water wells drilled from the 1700 level for the dual purpose of making water and reaching the mineralized zone. Ultimately the 2000 and 2250 crosscuts will connect to the bottom of the winze while a connection from the top of the winze to the surface will provide ventilation and a secondary exit from the stoping area.

Addenda

The draw down and recovery test previously described was completed on January 31, 1953.

The predicted volume and time required to unwater to the 2250 level, as well as the volume to hold at that level, are considerably in excess of the figures estimated from the experiences of 1948. Decision to postpone the major unwatering program has been made, pending further study.

The cost of power and the practicality of developing sufficient water to bring the time factor within feasible limits are the main problems. Larger expenditures than originally anticipated will demand additional information as to the tonnage and grade of ore to be mined.

Acknowledgments

The writer wishes to thank Thayer Lindsley, President of Eureka Corp. Ltd., for permission to write this paper and John K. Brozo, Chief Engineer, for making maps and giving helpful criticism.

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An Investigation of the Collecting Effects Of Fatty Acids in Tall Oil on Oxide Minerals, Particularly on Ilmenite

A preliminary investigation of the collecting effects of various fatty acids in tall oil has led to a conclusion that the collecting power of fatty acids used in flotation increases with increasing unsaturation of the hydrocarbon chain. Linoleic acid was found to be an excellent collector for oxide minerals.

by R. T. Hukki and O. Vartiainen

TALL oil is a mixture of fatty and resin acids extracted as byproducts in the sulphate pulp industry. In the field of flotation a well-known example of this type of product is Reagent No. 708 of the American Cyanamid Co. Its successful use as a flotation collector with many nonsulphide minerals has been described by Falconer and Crawford.[1]

The composition of crude tall oil varies within wide limits.[2, 3] By a number of methods the crude oil may be refined to produce a variety of refined products.

This investigation presents a preliminary comparative study of collecting properties of the fatty acids in tall oil. In Finnish tall oils these constituents are primarily palmitic, oleic, linoleic, and linolenic acids.[3] The first is a saturated fatty acid having 15 carbon atoms in its hydrocarbon chain, plus one in the carboxyl group. The others have 17-carbon-atom chains and are unsaturated. It is of particular interest to note that palmitic, oleic, linoleic, and linolenic acids represent increasing degrees of unsaturation with 0, 1, 2, and 3 double bonds, respectively.

To test the collecting properties of the four fatty acids separately, the vacuum flotation technique described by Schuhmann and Prakash[4] was used. By this method the boundary between flotation and nonflotation conditions was approximately delineated, with the use of ilmenite and several other minerals. Collector concentration and pH were the principal variables. On the basis of information obtained, actual flotation tests were run on an ilmenite-bearing ore in a laboratory flotation cell.

Through the courtesy of P. Kajanne from the Department of Chemistry, Finland Institute of Technology, the following reagents were obtained for this investigation: 1—Palmitic acid, of Judex, had a purity of 95 pct as determined by parallel iodometric and spectrophotometric measurements. 2—Oleic acid, product of May and Baker Ltd., indicated purity of 98 pct. By iodometric and spectrophotometric determinations the oleic acid content was found to be 83.8 pct. In addition, it contained 6 pct linoleic, 1 pct linolenic, and 9.2 pct saturated fatty acids.[5] 3—Linoleic acid was prepared from soybean oil by low-temperature crystallization. Its linoleic acid content was 95 pct by the methods indicated above. 4—Linolenic acid was prepared from linseed oil by low temperature crystallization. Its linolenic

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acid content was estimated by the two methods at only 65 pct, the balance being chiefly oleic and linoleic acids.

Palmitic acid was used as an aqueous suspension of potassium palmitate containing 5 pct ethanol. The others were used as such or in the form of sodium salt solutions.

In vacuum flotation tests, 100 to 200 mesh fractions of ilmenite ($TiFeO_3$) concentrate assaying 48.2 pct TiO_2 were used. The concentrate was prepared from Otanmäki ore by tabling and multiple cleaning of the table concentrate by low and high intensity magnetic separation.

Minerals

Similar samples were also prepared of Otanmäki magnetite, Fe_3O_4, and pyrite, FeS_2. For a comparison, samples of Otanmäki hornblende with a certain amount of chlorite and biotite were tested as representatives of respective gangue silicate minerals. In addition, small samples of high grade hematite, Fe_2O_3, and rutile, TiO_2, of unknown origin were prepared as examples of oxides that are similar to ilmenite and magnetite.

One-gram samples of mineral, 100 ml of water of suitable pH, and the reagent under investigation were introduced into the thoroughly cleaned vacuum flotation cylinders, which were then closed with glass stoppers. For 25 min the cylinders were tumbled in the frame at a speed of 41 rpm. After this conditioning, glass stoppers were removed and rubber stoppers attached to an inserted vacuum line. Dissolved air was allowed to precipitate out under vacuum so that conditions of flotation and non-flotation might be observed. Full flotation was indicated by the accumulation of all mineral particles with ascending air bubbles at the air-water interface. Non-flotation was revealed by the total passivity of mineral particles toward air bubbles. In the latter case, all the particles were retained in the bottom of the cylinder.

Fig. 1 is typical of the results obtained by the Schuhmann-Prakash method. It shows the flotation conditions for ilmenite. The coordinates are respectively pH, or log hydrogen-ion concentration, and log collector addition. This figure shows flotation to be possible inside the closed curves. The extreme boundaries for the linoleate reagent are not known. The position of the curves is approximate, since the Schuhmann-Prakash method gives semi-quantitative results only, but with great rapidity.

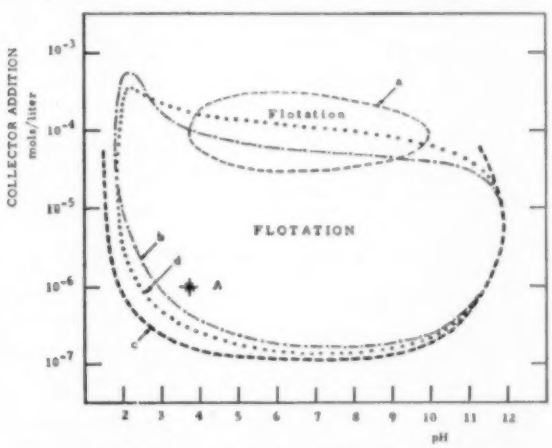

Fig. 1—Delineation of the experimental results of vacuum flotation tests on ilmenite with a—potassium palmitate, b—sodium oleate, c—sodium linoleate, and d—crude sodium linolenate. The graphs indicate the transfer boundaries between non-flotation and flotation, but do not show whether flotation is poor, good, or excellent. The quantitative behavior at point A of the linoleate and oleate soaps is shown by photographs in Figs. 2a and 2b.

Results of Experimental Techniques

The observations of about 550 separate tests conducted by vacuum flotation method may be summarized as follows:

1—The four fatty acids act as collectors of ilmenite over a wide pH-range.

2—The collecting power of linoleic acid, or of the respective sodium soap, is superior to that of oleic acid, or of sodium oleate. This is clearly shown in Figs. 2a and 2b.

3—The collecting power of oleic acid is much stronger than that of palmitic acid.

4—The collecting power of the crude linolenic acid available to us is intermediate between that of linoleic and oleic acids.

5—The superiority of linoleic acid over oleic acid is equally pronounced with magnetite, hematite, and rutile as with ilmenite.

6—When linoleic acid is used as collector, the air bubbles appear completely armored with mineral particles, while in the other cases under similar experimental conditions only a part of bubble surface is covered with the mineral as shown by comparison of Figs. 2a and 2b.

7—All four fatty acids act as collectors of pyrite over roughly the same pH-range as in case of ilmenite.

8—The collecting power of the fatty acids on silicates, e.g. hornblende, is definitely inferior to that on metallic oxides. With the fatty acids under investigation, it appears to be in the order palmitic < linoleic < linolenic < oleic acid.

Discussion

These observations have led the authors to the following theorem: The collecting power of fatty acids used in flotation increases with increasing unsaturation of the hydrocarbon chain.

This is supported by tests conducted with palmitic, oleic, and linoleic acids. It is not supported by tests with linolenic acid. The sample of linolenic acid used, however, contained only 65 pct linolenic acid. Consequently results cannot be regarded as proofs against the above theorem.

In this connection it is of interest to compare the investigations of Keck, Eggleston, and Lowry.[6] They report that the collecting power on hematite of the fatty acids they tested was in the order of oleic > lauric > myristic > palmitic > caprylic acid. This order in no way contradicts the observations summarized in this paper since lauric, myristic, and caprylic acids represent saturated fatty acids. In the paper describing flotation of magnetite, Keck and Jasberg[7] state that "unsaturated oleic acid with 18 carbon atoms was a better collector than saturated stearic acid, which also has 18 carbon atoms" and that with the saturated fatty acids flotation increased with the number of carbon atoms.

The observations made by the present writers indicate that selective separation of pyrite from heavy metal oxides with fatty acid collectors will be difficult without modifying reagents. On the other hand, separation of oxides from certain silicates appears possible without modifying reagents and over a considerable pH-range.

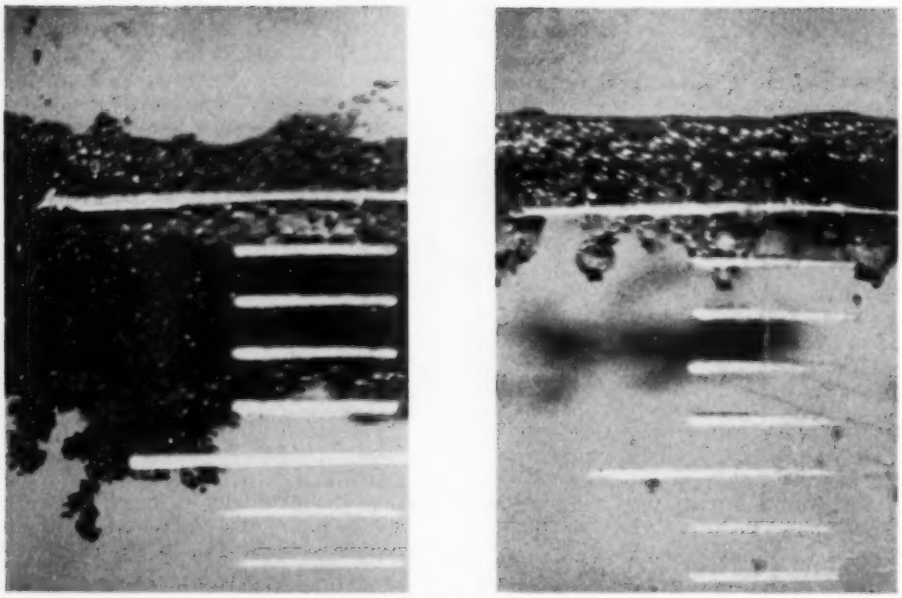

Fig. 2a—A photograph of vacuum flotation tests on ilmenite with linoleic acid, and Fig. 2b—with oleic acid. In these tests, 0.001 millimols of Na-linolate and an equal amount of Na-oleate were used at pH 3.7 for 1-g samples of 100 to 200 mesh ilmenite. Note how fully laden the tiny air bubbles are as shown in Fig. 2a, how completely covered the bubbles appear, and how thick the froth layer is when all particles are floated. In the test illustrated in Fig. 2b the coalescence of small bubbles has been less hindered and thus larger bubbles have formed. Each bubble is only partly covered with ilmenite, and the froth layer is relatively thin and carries only a fraction of the total sample.

In view of the fact that the sulphate cooking process effects well-known alkali isomerization phenomena in the double bond structure, it is important to note that further investigations are needed to reveal the collecting power of different linoleic acid isomers.

On the basis of the above work it was of interest to test the applicability of the described theorem in actual flotation tests. The general rule in flora is that the fatty acids contained by plants increase in degree of unsaturation with increasing latitude.[8] Therefore samples of tall oil extracted from pines grown in northern Finland would have been highly desirable. At our request, several samples of such tall oils were submitted by Oulu Co. In the processing of crude tall oil, palmitic acid seems to concentrate to first fractions relatively low in resin acids, oleic acid in the middle fractions, and linoleic acid in the last fractions richer in resins. (Their resin content was 25 to 40 pct.)[9] The amount of linolenic acid in the crude tall oil is low, of the order of 2 pct,[9] and can be disregarded. The effect of resin acids in tall oils on flotation is somewhat obscure. Their collecting power in the pure state is unknown to the authors, but they seem to cause a certain amount of frothing.[9, 10]

Although no exact analyses of the fatty acid distribution in the samples of tall oils submitted were available, those samples in which the linoleic acid content was highest gave the best results in the laboratory flotation experiments with Otanmäki ilmenite ore. As a matter of fact, one such tall oil reagent gave concentrates assaying 44 to 46.8 pct TiO_2, the maximum being about 48.5 pct TiO_2 with this ore, representing recoveries of 75 to 79 pct out of a deslimed ore assaying 15 pct TiO_2. About 10 pct increase in recovery would result in continuous practice from the retreatment of flotation middlings. These results are at least equal if not superior to those obtained under the same experimental conditions with any other conventional reagent including many of foreign manufacture.

Conclusions

1—A number of oxide minerals of economic importance can be concentrated with tall oil collectors of domestic Finnish origin. 2—Tall oils rich in linoleic acid are superior to fatty acid collectors conventionally used. 3—New flotation reagents of superior collecting power can be developed for flotation of oxide minerals. 4—The development of a means of commercial production, at a reasonable cost of, for example, linoleic acid of sufficient purity and proper isomeric constitution, would be of worldwide interest in the flotation of oxide minerals.

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aime NEWS

One of the highlights of the Hibbing Meeting promises to be the trip to the Babbitt concentrator of Reserve Mining Co. An impressive list of plant and mine visits has been prepared for the meeting, scheduled for August 31 to September 2.

Committee Unfolds Hibbing Meeting Plans

The Convention Committee for the Hibbing, Minn., meeting of Minerals Beneficiation Div., August 31 to September 2, disclosed some of the plans being made for the gathering.

Leading off the morning orientation program will be G. M. Schwartz, director of Minnesota Geological Survey, who will discuss *Geology of the Mesabi Range as it Affects Beneficiation*. B. M. Andreas will talk on *Present Trend in Mesabi Range Mining*. Henry H. Wade will speak on *Beneficiation of Mesabi Ores*.

Afternoon technical papers will include *Taconites—Their Chemical and Physical Characteristics Affecting Concentration*, by Donald W. Scott; *Iron Ore Separation in the Cyclone*, by Earl C. Herkenhoff; and a paper by Ronald J. Morton.

A full schedule of plant trips has been arranged. The types of plants to be visited have been determined but plans may be changed somewhat as the situation directs.

Tuesday, September 1—Trip east of Hibbing

Reserve Mining Co., Babbitt, Minn.,

A. The Babbitt concentrator of Reserve Mining Co., Babbitt, Minn., or the "Pilotac" Plant of the U. S. Steel Corp.'s Oliver Iron Mining Division, Mt. Iron, Minn. Both taconite magnetic concentration plants.

B. The "Extaca" Plant of the Oliver Plant Mining Division, Virginia, Minn. Sintering machine and rotary kiln for agglomeration of taconite concentrate.

C. The Coons-Pacific Plant of the Pacific Isle Mining Co., Eveleth, Minn. Washing, heavy-media, jigs, and spirals.

D. The Mary Ellen Plant, Pioneer Mining Co., Biwabik, Minn. Washing and heavy-media.

E. Charleson Plant of the Charleson Iron Mining Co., Virginia, Minn. Jigs.

Wednesday, September 2—Trip west of Hibbing

A. Hawkins Mine and Plant, Cleveland-Cliffs Iron Co., Nashwauk, Minn. Washing, heavy-media, cyclones, spirals.

B. Holman Mine and Plant Cleveland-Cliffs Iron Co., Taconite, Minn. Washing, heavy-media, cyclones, spirals

C. Lake Concentrator, Cleveland-Cliffs Iron Co., Taconite, Minn. Washing, heavy-media, spirals

D. Trout Lake Concentrator, Oliver Iron Mining Division, Coleraine, Minn. Washing and abrasion milling.

E. Hill-Annex Plant, Jones & Laughlin Steel Corp., Calumet, Minn. Washing, heavy-media, cyclones, spirals

F. Morton Mine, M. A. Hanna Co., Hibbing, Minn. Conveyor-stripping operation

G. Agnew and S. Agnew Mines, M. A. Hanna Co., Hibbing, Minn. and the Hull-Rust-Mahoning group, Hibbing, Minn.

Engineering Society Secretaries Convene

On June 5 and 6 between 30 and 40 representatives of national and local engineering societies met at the Haddon Hall Hotel in Atlantic City for the annual meeting of the Council of Engineering Society Secretaries. O. Laurence Angevine, of the Rochester Engineering Society, presided, as Council president. Papers were read on Managing Publications; Meeting Increased Costs in Society Operation; Promotional Material; Aims, Purposes, and Operation of ASTM; and Organizing for Community Activity Under ECPD Training Program. Highlight of the program was a panel discussion of Modern Office Procedure, in which the new equipment and methods in use by the AIME attracted much attention. The AIME had three representatives present: E. H. Robie, Secretary; P. J. Apol, Business Manager; and H. N. Appleton, Assistant Secretary for Institute Activities. Officers elected for the coming year are as follows: Ernest Hartford, executive assistant secretary ASME, president. Edward H. Robie, Secretary AIME, vice-president. M. C. Turpin, secretary American Society of Refrigerating Engineers, secretary. Charles S. Doerr, secretary Engineers Club of Philadelphia, treasurer. T. J. Ess, managing director, Assn. of Iron and Steel Engineers, director for three-year term. Other directors continuing to serve are: J. Earl Harrington, secretary, Western Society of Engineers; H. H. Henline, secretary, AIEE; and O. L. Angevine, secretary of the Rochester Engineering Society.

New Subsection Formed

A Subsection of the St. Louis Local Section has been authorized, to be known as the Arkansas-Bauxite Subsection. The new Subsection embraces all that part of Arkansas north of and including the following counties: Polk, Montgomery, Hot Spring, Grant, Jefferson, Arkansas, and Phillips. A part of this territory had formerly been in the field of the Lou-Ark and Tri-State Sections.

Final Details Complete for Nova Scotia Session

Preparations are complete, bags are being packed, and Nova Scotia awaits the influx of AIME members who are planning to attend the joint meeting of the Industrial Minerals Div., and the Canadian Institute of Mining and Metallurgy with the Mining Society of Nova Scotia.

Registration for the meeting begins at the Isle Royale Hotel, Sydney, N. S., at 3 pm September 7 to noon September 8. After that time registration will be at the Keltic Lodge. The Committee requests that those attending the meeting register as soon as possible and that side trips be selected at the earliest feasible time. Those who do not bring cars to Nova Scotia are asked to notify the registration desk upon arrival so that transportation can be arranged. In addition, in order that the rather full schedule be carried out without delay, the committee emphasized that get-a-way times must be observed religiously.

Comprehensive abstracts of all papers at the meeting will be available at time of presentation. Discussion is invited on all papers.

Luncheons and dinners will be open to men and women, and the distaff side is cordially invited to attend any field trips of interest to them. Among the recreational facilities available are tennis, golf, lawn bowling, quoits, darts, archery, shuffle board, ping-pong, card parties, and lagoon and ocean bathing. Fishing parties can be arranged with sufficient notice. *Dress will be informal on all occasions.*

The vista from the Keltic Lodge, headquarters for the Nova Scotia Meeting, offers an impressive view of the sea and sky. In addition to top flight accommodations the Lodge offers a full schedule of sports and amusements.

Committees

Preliminary Planning Committee: M. F. Goudge, Chairman; S. S. Cole; Ian Campbell; C. M. Cooley; H. M. Bannerman; S. C. Mifflen; E. D. Brown; D. J. MacNeil; Mrs. S. S. Cole; and J. A. Russell.

General Committee on Arrangements: D. J. MacNeil, Chairman; S. C. Mifflen; E. D. Brown; J. A. Russell, ex-officio; R. Charlick, ex-officio; H. M. Bannerman, Chrmn., I. M. D., AIME; and ex-officio, T. H. Janes, Chrmn., I. M. D., C. I. M. M.

Papers Committee: S. S. Cole, Chairman; J. G. Broughton; H. M. Bannerman; C. M. Cooley; M. F. Goudge; D. J. MacNeil; R. C. Stephenson; S. C. Mifflen.

Ladies Committee: Mrs. W. S. Wilson, Chairman; Mrs. E. D. Brown; Mrs. J. C. Eaton; Mrs. D. J. MacNeil; Mrs. R. L. Riley; Mrs. S. S. Cole of AIME; Mrs. C. Gerow of CIMM.

MONDAY, SEPTEMBER 7

3:00 to 11:00 pm
Registration and selection of side trips for both men and women

8:30 to 10:00 pm
Open House Reception

TUESDAY, SEPTEMBER 8

8:30 am
Registration continues

9:30 am
Leave Isle Royale Hotel on tour to Fortress of Louisbourg

9:45 am or
Leave Isle Royale Hotel for inspection of processing slag at plants of Dominion Iron & Steel Ltd. and L. E. Shaw Ltd.

12:00 m
Inaugural reception

12:30 pm
Luncheon

2:30 pm
Leave Isle Royale Hotel by car for Keltic Lodge

5:00 to 5:30 pm
Arrive Keltic Lodge

7:00 pm
Social hour

7:30 pm
Dinner

9:30 pm
Film: Scenic Nova Scotia

For interested parties additional, nonscheduled side trips as below may be arranged for this date if requested on *September 7 or earlier.*

(1) Inspect DOSCO Miner in operation in a Dominion Coal Co. colliery. For men only. Cars will leave Isle Royale Hotel at 8:00 am

or

(2) Inspect steel plant and/or byproduct coke ovens of Dominion Iron & Steel Ltd. Cars will leave Isle Royale Hotel at 9:15 am

WEDNESDAY, SEPTEMBER 9

10:00 am
Industrial Minerals in the Chemical Industry: J. R. Donald
Properties and Application of Iron Blast Furnace Slag: J. R. Wallace, N. Weiner, and P. Fedora
Geology and Mining of Nova Scotia Gypsum: N. R. Goodman and C. B. Hume

1:00 pm
Luncheon

2:30 pm
Leave Keltic Lodge for:

(1) Inspection of quarry and plant of National Gypsum Co. (Canada) Ltd.

or

(2) Drive on Cabot Trail through Cape Breton Highlands National Park.

6:30 pm
Social hour

7:00 pm
Dinner

9:00 pm
Sound Films:

(1) Photogeology

(2) Bricks from the Sea

(3) Nova Scotia Industries
(4) Sulphur

THURSDAY, SEPTEMBER 10

10:00 am
Petrology and the Industrial Minerals: Ian Campbell
Newfoundland Fluorspar: G. F. Carr
Phosphate Rocks as an Economic Source of Fluorine: W. L. Hill and K. D. Jacob
Some Geologic Features of a Potash Deposit: C. L. Jones
1:00 pm
Luncheon
2:30 pm
Sports Contests: Golf, tennis, archery, darts, lawn bowling, shuffle board, quoits, ping-pong, cards (Entrants to hand in their names before 9:00 pm on previous day)
5:00 pm
Executive Meeting
Industrial Minerals Div., AIME
6:30 pm
Social hour
7:00 pm
Dinner
9:00 pm
Dancing

FRIDAY, SEPTEMBER 11

10:00 am
Development of a Mine Appraisal Method in New York State: J. J. Prucha and J. R. Thorne
Chemical and Mineralogical Characteristics of Titaniferous Concentrates from North Carolina, Quilon, Brazil, and Florida Beach Sands: L. E. Lynd, H. Sigurdson, C. H. North, and W. W. Anderson
Importance of Water in Industry: J. F. J. Thomas
1:00 pm
Luncheon
2:30 pm
Barites Resources of Nova Scotia: C. O. Campbell
Kyanite in Canada: V. A. Haw
Methods of Proving Worth of Clay and Shale Deposits: J. F. McMahon and W. Brownell
6:30 pm
Social hour
7:00 pm
Dinner
Award of prizes in sports contest
9:00 pm
Fun parade

SATURDAY, SEPTEMBER 12

9:00 am
Leave Keltic Lodge for Antigonish
12:30 pm
Roadside lunch at Port Hawkesbury and ferry across Canso Straits to Mulgrave immediately thereafter
1:30 pm
Leave Mulgrave
2:30 pm
Arrive St. Francis Xavier University, Antigonish
3:15 pm
Special Convocation, St. Francis Xavier University
5:15 pm
Reception
5:45 pm
Dinner
Compliments of the Government of Nova Scotia, The Board of Governors, St. Francis Xavier University
7:45 pm
Leave Antigonish
11:15 pm
Arrive Halifax

SUNDAY, SEPTEMBER 13

The party splits to reunite at 4:00 pm

Party No. 1

9:00 am
Leave Lord Nelson Hotel for Walton
11:00 am
Inspect barites quarry and plant of Canadian Industrial Minerals Ltd.
1:00 pm
Luncheon
2:30 pm
Leave Walton
4:00 pm
Arrive Mt. Uniacke Museum and rejoin party no. 2

Party No. 2

10:00 am
Sail on Halifax Harbour, Compliments, Royal Canadian Navy
Luncheon
2:30 pm
Leave Lord Nelson Hotel for drive through Halifax
4:00 pm
Arrive Mt. Uniacke Museum and rejoin party no. 1
5:00 pm
Leave Mt. Uniacke Museum
6:00 pm
Arrive at shore for cocktails
7:00 pm
Dinner (lobster boil)
8:30 pm
Consistory: The Order of the Good Time—admission of new members
Other recreation
Return to hotel

For the Ladies

The Ladies will, of course, participate in all main functions throughout the meeting but for the periods taken up by technical sessions.

Golf, tennis, etc. are available at all times and one good feature about Keltic Lodge is the opportunity to arrange on the spot for almost any form of entertainment which may be desired.

WEDNESDAY, SEPTEMBER 9

11:00 am
Coffee party
2:30 pm
Drive on Cabot Trail through Cape Breton Highlands National Park
9:00 pm
Card party—bridge and canasta

THURSDAY, SEPTEMBER 10

10:00 am
Hike over a scenic part of the golf links or through the woods to The Point

FRIDAY, SEPTEMBER 11

10:00 am
Leave Keltic Lodge for St. Ann
12:00 m
Picnic lunch at St. Ann
1:30 pm
Inspection of Gaelic Craft Centre with looms, etc. in operation
3:30 pm
Leave St. Ann for return to Keltic Lodge

SATURDAY, SEPTEMBER 12

4:00 pm
Inspect pottery school at Mt. St. Bernard, Antigonish

Board to Take Action on Proposed Bylaw Changes September 22

Local Sections

At the meeting of the Inter-Branch Council in Los Angeles, Feb. 15, 1953, a resolution was passed recommending that the AIME Board of Directors change the bylaws so that more than one Local Section in a given geographical area be permitted. The reasoning was that in certain Local Section areas, Divisional or Branch interests could be served better if a Local Section devoted to their specific interests were organized. Heretofore, Local Sections whose membership had diverse professional interests either had little to offer members in their particular professional field, or operated through loose sponsorship of small groups or subsections. In some Sections such organization was satisfactory, in some others not.

The Executive and Finance Committees considered the resolution at their meeting on April 15, and the Board discussed the matter further at the meeting of June 17. No particular objection was offered to the idea of overlaying Local Sections provided the Council of Section Delegates is not unduly enlarged thereby and that the cost of supporting Local Section activities does not increase. In any case, the proposed change in the bylaws would be permissive only, as to establishing overlaying Local Sections, and no Section could be established or continue in existence without approval of the Board. This would give the Board authority to take action on canceling a Local Section if cause therefor developed. It was generally agreed that Section Delegates should represent areas rather than Local Sections if the plan were in effect.

The Board voted to propose to delete the following words from Article XI, Section 3, of the bylaws (page xlvii, 1st column, of the 1952-53 Directory): "Only one Section shall be authorized in any one locality or district and . . ."

The Board will vote on this change in the bylaws at its meeting in Seattle on Sept. 22. If the change is authorized at that time, members will be advised of the procedure to be followed in setting up new Local Sections in areas already covered.

Meeting Papers

Heretofore, the AIME bylaws have not been specific as to the ownership of papers presented at Institute meetings. The only such reference in the bylaws is in Section 3 of Article XI, which states that "Papers presented at Local Sections, and discussions thereon, if reported, shall be the property of the Institute. Such papers shall not be published elsewhere in extenso without permission of the Board." Questions have often arisen as to publication rights of other papers.

Three years ago a committee, consisting of H. A. Meyerhoff, Chairman, with R. M. Foose and C. C. Long, was named to study the matter of the ownership and release of technical papers presented at AIME meetings. Reports of the committee, and staff discussions thereon, have been recorded in the minutes of various meetings of the Board. Proposed amendments to the AIME bylaws, which will be voted on at the Sept. 22 meeting of the Board, seem to meet with general approval, and the Board, at its meeting on June 17, directed that they be published.

It is proposed to amend Article 10 (page xlvi in the current Directory) by adding Section 2, which would read as follows:

All papers presented before meetings of the Institute—Annual, Regional, Branch, Divisional, and Local Section—are the property of the Institute, except those previously published elsewhere, those withheld from publication by the author, or those released by the Secretary of the Institute.

It is also proposed that the sentence above quoted in Article XI, Section 3, be amended as follows:

Papers presented at Local Section meetings, and discussions thereon if reported, shall be the property of the Institute, except those previously published elsewhere, those withheld from publication by the author, or those released by the Secretary of the Institute. (The sentence immediately following, beginning "Such papers," is to be deleted.)

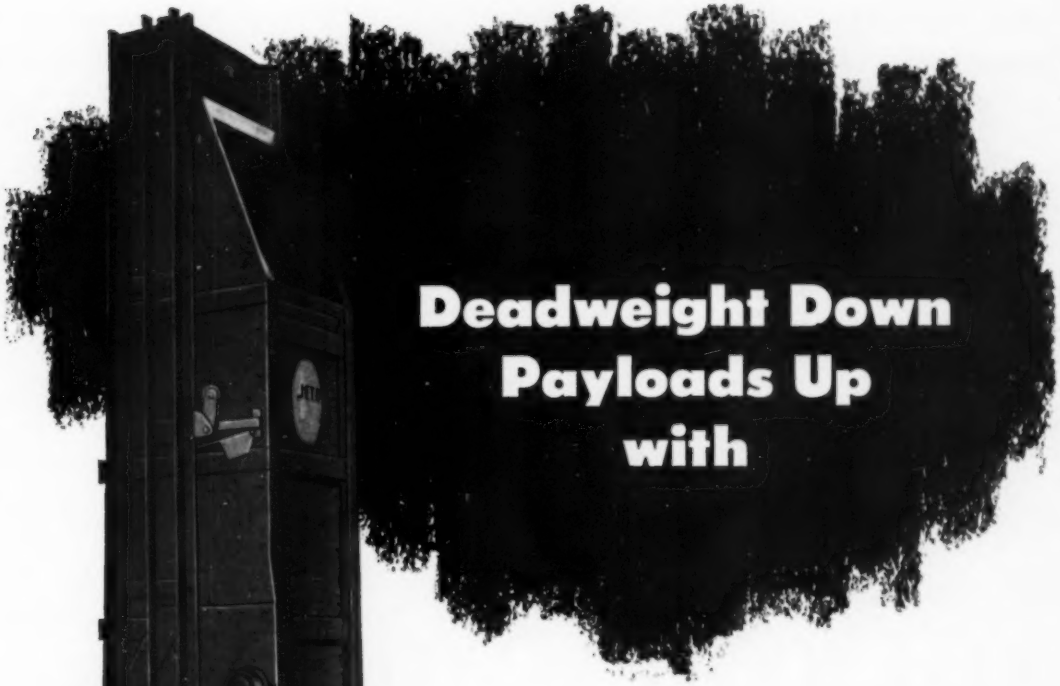
Apportion Duties Of Institute Officers

Heretofore, AIME Vice-Presidents and the President-Elect have been given no specific duties or responsibilities, nor has the Nominating Committee had any instructions as to the selection of Vice-Presidents. The President each year has had to assume all the burden of travel to Local Sections and Student Chapters, and with well over a hundred such visits expected, Presidents have done well to reach a half of the Sections and a quarter of the Chapters.

A committee, consisting of L. E. Young, Chairman, with Leo F. Reinartz and O. B. J. Fraser, was recently appointed to suggest a better division of duties and responsibilities among the highest officers of the Institute. Their report, made at the June 17 meeting of the Board follows:

"(1) Recommend no changes in districts at this time. (2) For the present, retain six Vice-Presidents. (3) In 1953, Vice-Presidents, President-Elect, and President shall constitute a committee, which, for the present, will agree voluntarily to arrange a schedule with the Secretary of the Institute to visit the Sectional, District, and National Conferences, and as many Student and Local Chapters as possible this year. It is understood and deemed desirable that the President is privileged to call upon any Director in a given area to act as his representative in case he, the President-Elect, or one of the Vice-Presidents cannot attend certain meetings in that area. (4) Apportion the present ten Directoral Districts to the President-Elect and the six Vice-Presidents in such a way that each area served by an officer of the Institute would have equal membership. (5) Instruct future Nominating Committees to select candidates for the Vice-President's office in such a way that there will be a more equitable distribution of such individuals according to the territories of the AIME. (6) The officer chosen for a given district should interest himself in the Local and Student Chapters in his district in such a way that he may help in solving local problems, encourage new memberships, and in general assist in improving the services of the Institute to the members in his area, as well as presenting to the Board of Directors the views and aspirations of the membership he represents. (7) It is proposed that, after 1953, at the beginning of each Institute year the President shall call together the Vice-Presidents and President-Elect to discuss with them and the Secretary of the Institute basic Institute policies, practice, financial condition, membership problems, future program, and any other information of value to the officers. The Secretary shall prepare each year a manual of pertinent information about the Institute's policies and practices for use by the officers and Directors in that year. (8) It is proposed that, at the above-mentioned meeting, a schedule of visits to various local, district, and national meetings shall be presented by the Secretary for discussion, approval, and action by the group."

The report was accepted by the Board, and the Secretary was directed to proceed immediately to carry out the recommendations.



Deadweight Down Payloads Up with

LAKE SHORE MINING EQUIPMENT

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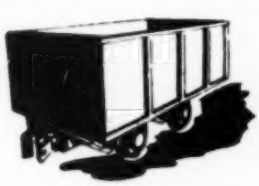

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Mining Branch Nominations for 1954

Nominations of AIME Officers for 1954 were published in the July MINING ENGINEERING pages 722-723. This is the complete list for officers of the Mining Branch and its Divisions.

Mining, Geology & Geophysics Div.

Chairman: James D. Forrester; Chairman Mining Subdivision: W. H. Goodrich; Chairman Geology Subdivision: Harrison Schmitt; Chairman Geophysics Subdivision: T. Koulomzine; Secretary-Treasurer: C. M. Cooley.

Minerals Beneficiation Div.

Chairman: S. D. Michaelson; Associate Chairman: Will Mitchell, Jr., Regional Vice-Chairmen: W. B. Stephenson, Norman Weiss; Secretary-Treasurer: Wayne L. Dowdey.

Industrial Minerals Div.

Chairman: R. C. Stephenson; Eastern Vice-Chairman: Raymond B. Ladoo; South Eastern Vice-Chairman: Oscar M. Wicken; Canadian Vice-Chairman: Alan E. Cameron; Rocky Mountain Vice-Chairman: W. F. Rappold; Western Vice-Chairman: M. L. Leonardi; Pacific Northwest Vice-Chairman: Leslie C. Richards; Secretary-Treasurer: C. M. Cooley.

Minerals Industry Education Div.

Chairman: J. R. Van Pelt, Jr.; Vice-Chairman: J. W. Stewart; Secretary: J. D. Forrester; Executive Committee: R. E. Kirk, E. P. Pfleider, W. T. Thom, Jr.; Past Chairman: Harry H. Power.

Coal Div.

Chairman: Maurice D. Cooper; Chairman Elect: H. F. Yancey; Secretary-Treasurer: D. R. Mitchell; Executive Committee (1954-1957): W. L. Wearly, E. C. Payne, John P. Weir.

Mineral Economics Div.

Chairman: J. K. Richardson; Vice-Chairmen: James Bradley, L. C. Raymond, Allan F. Matthews; Secretary-Treasurer: Richard M. Foose; Executive Committee: A. O. Bartell, John Ffolliott, Paul Turnbull, L. N. Thomas.

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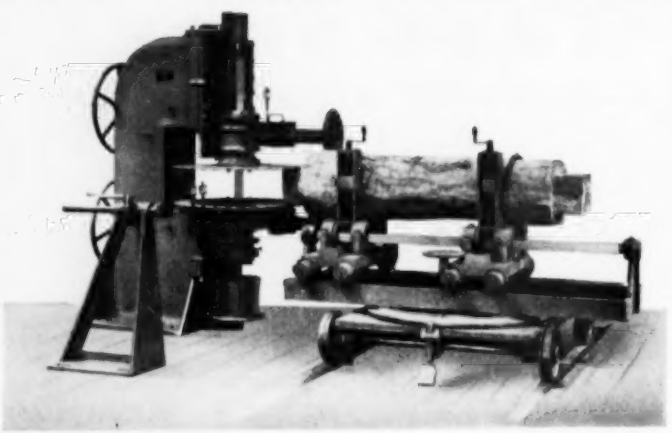

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MGGD Honors Approved By Board

At its meeting on June 17, the Board of Directors gave tacit approval to a proposal that a Lectureship and an Award to young men for the best paper in the field of the Mining, Geology, and Geophysics Div. be established. C. M. Cooley, Secretary of the Mining Branch, was directed to develop the details of the plan. The proposal emanated from the MGG Div. The Lectureship will be named in honor of D. C. Jackling and will be an annual invitational address presented at the Annual Meeting by an outstanding man in the field of the Div. Similar Lectureships have been established by the Institute of Metals and the Iron and Steel Divs.

The other award will be granted to the person or persons, not over 40 years old, who has or have submitted an outstanding paper in the field of the MGG Div. A cash prize accompanied by a certificate is planned, the award to be made at the annual Mining Branch Dinner. Complete details remain to be worked out and approved.

AIME Supports EJC In UPADI Financing

AIME Directors have voted the sum of $603 from the Eilers Fund as a contribution to Engineers Joint Council which will be used to finance UPADI (Union Panamericana de Asociaciones de Ingenieros) activities on a restricted scale during the current year. The contribution, totaling some $4500, is in the form of a loan to the UPADI Fund. When financing is completed it is expected that the loan will be repaid.

H. N. Eavenson Wills $150,000 to Institute

Terms of the will of the late Howard N. Eavenson, President of the Institute in 1934, were recently made known to AIME Directors. The money will be available as a trust fund after the death of Mrs. Eavenson, and the income is to be used for the following purposes: (1) To defray the cost of publishing papers of interest to members of the Coal Div. (2) To establish the Howard N. Eavenson Award to amount to at least $500, with an engrossed certificate, to be given from time to time to a person who has contributed the most to the advancement of the coal industry. (3) For other purposes of the Coal Div. if the annual income is not used as specified in (1) or (2).

This large gift will bring the total general endowed funds of the AIME to approximately $960,000. The principal other Funds are the James Douglas Library Fund, $110,000; Rocky Mountain Club Fund, $114,000; Seeley W. Mudd Fund, $106,000; George D. Barron Fund, $133,000; and Henry L. Doherty Fund, $98,000.

AIME Nominating Practice To Be Reviewed

Following suggestions made by the Chicago Section, AIME, and the Minerals Beneficiation and Coal Divs. that a committee be appointed to review the present method of nominating AIME officers, the Board, at its June 17 meeting, named the following to serve on such a committee: J. B. Morrow, Chairman; Clayton G. Ball, L. E. Elkins, W. M. Peirce, W. B. Stephenson, and Andrew Fletcher, ex officio. The present procedure is detailed in Article IX of the Bylaws (page xlv of the current Directory) and in "Information and Advice to Members of the AIME Nominating Committee" (page xxxi). The committee will appreciate hearing from individual members or groups who have constructive suggestions to offer for improvement, or who wish to commend the present rules. These were extensively revised just three years ago by the Board, following recommendations of another committee appointed for the purpose.

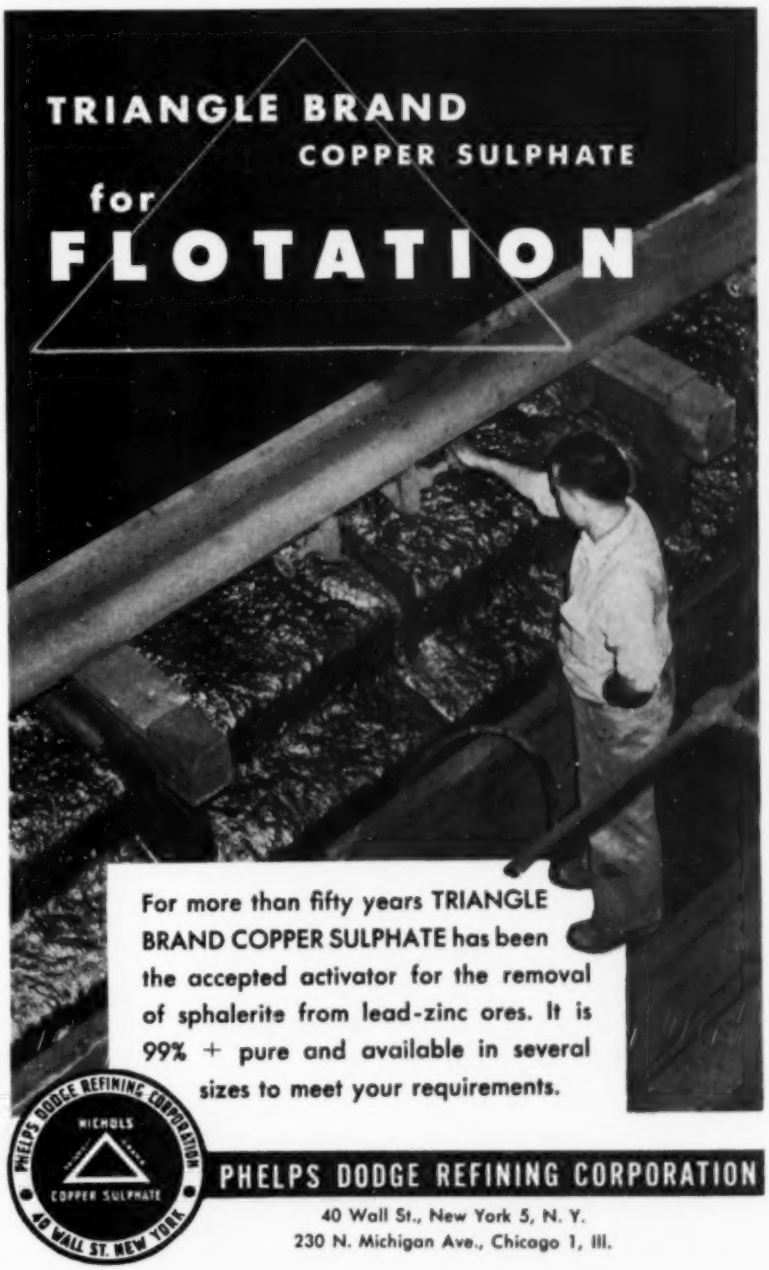
Increase Local Section Appropriations

Reduced appropriations to Local Sections for 1953 were not questioned by a majority of the Sections but 15 or so expressed opposition to the action for one reason or another. The Board considered these objections at its meeting on June 17, and voted to increase the current distribution to a total approximately the same as that distributed in 1952 and the immediately preceding years, or to approximately $10,000. The earlier allotment had totaled $7700 after increases had been made in four cases. The Committee was to make a further study of the matter in July and to recommend increasing the allotments to some of the Local Sections whose treasuries appear to be most in need of support. It is expected that the Council of Section Delegates will study the matter carefully, discuss it at its meeting next February, and make a recommendation to the Board as to the degree of financial support to be accorded Local Sections in the future.

Directory Issued By Petroleum Branch

The Petroleum Branch has just issued an up-to-date directory of its members. Copies may be obtained by addressing the office of the Petroleum Branch, 800 Fidelity Union Bldg., Dallas 1, Texas.

A supplement to the all-Institute Directory, giving a list of the 1953 officers of the Institute and its Branches, Divisions, Local Sections, and Student Chapters, committee personnel, and representatives, has been mailed to all paid-up AIME members.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Around the Sections

• Phelps Dodge Corp. played host to a one-day meeting of the Smelting Div., **Arizona Section,** at the New Cornelia Branch at Ajo. Forty-two registrants toured the smelter and were served luncheon at the copper loading dock. Three papers were presented at the afternoon session. They were: *Metallurgy of the Ajo Smelter,* by F. W. Denny; *Design and Operation of Ajo Reverberatory Furnace,* by W. C. Hunter; and *Ajo Anode Practice,* by A. H. Lyons. All are with Phelps Dodge. A cocktail party and dinner that evening were attended by 103 persons.

• C. R. Kuzell, general manager of the Phelps Dodge Corp., talked on *Labor Relations* to the **Bisbee-Douglas Subsection.** Meeting was held at the Bisbee Country Club.

• At a meeting of the **Tri-State Section** Andrew Fletcher, AIME President, discussed *Highlights of Domestic Lead and Zinc Situation.* Ralph Kirk, AIME Director and in charge of the raw materials div. of U. S. Steel Corp., also spoke to the group. The meeting was a dinner-dance affair.

• M. L. Leonardi, crystallizer superintendent, presented a paper on the *American Potash and Chemical Co.'s Operations at Trona, Calif.* at a recent meeting of the **Carlsbad Potash Section,** Carlsbad, N. M. W. P. Wilson, Section Chairman, discussed new membership contests.

• About 190 persons attended a technical meeting sponsored by the **Southeast Section** at Moundville State Park, Ala., with E. H. Rose presiding over the meeting. Seven papers were presented. Walter B. Jones, geologist, Geological Survey State of Alabama, offering was *How to Eat Barbecue.* Serious papers were *A Preliminary Investigation of the Bagdad, Arizona, Copper Ore,* by Norman I. Hyman; *Principles and Modern Applications of Gas Lift,* by Steve H. Finch; *The Alabama School of Mines and the Mineral Industry,* by J. W. Stewart, *A Few Color Slides from Denmark,* by Niels N. Engel; *The Manufacture of Pig Iron Without Metallurgical Coke,* by E. C. Wright; and *The Relation of Carbon Equivalent to the Properties of Cast Iron* by W. C. Jeffery.

• Gordon Herreid, U. S. Geological Survey, addressed members of the **Alaska Section** on *Reconnaissance Geology* at a meeting at College, Alaska. John Boswell, U. S. Smelting, Refining & Mining Co., spoke on *Placer Mine Research Possibilities.* Other speakers were Robert Saunders, N. R. Mukherji, and Commander Jensen.

• **The Black Hills Section** held a meeting in honor of Mr. and Mrs. Guy N. Bjorge. Mr. Bjorge is retiring as general manager of the Homestake Mining Co. The Black Hills Section was founded largely through the efforts of Mr. Bjorge. Nathaniel Herz, chief metallurgist at Homestake, traced the career of Mr. Bjorge. Warren Wilson, president of the South Dakota School of Mines and Technology described the cordial relationships among the school, Mr. Bjorge, and Homestake.

EJC To Be Enlarged

Enlargement of Engineers Joint Council to include other engineering societies makes certain changes in its constitution advisable. At the June 17 meeting of the AIME Board, these changes, giving the qualifications under which a national engineering society might become a constituent body, were approved. They would provide: (1) The corporate or voting membership shall be confined to individual members (not corporations or company members). (2) A majority of individual members shall be either graduates of engineering colleges of recognized standing or shall be licensed or registered by a State Board of Registration for Professional Engineers. (3) The society shall have a total membership of at least 5000 individual members of which the majority must meet the above requirements. (4) Request for admission shall receive the affirmative vote of not less than two thirds of the constituent societies of the Council.

At present, EJC comprises the ASCE, AIME, ASME, AIEE, AIChE, Society of Naval Architects and Marine Engineers, American Society for Engineering Education, and American Water Works Assn.

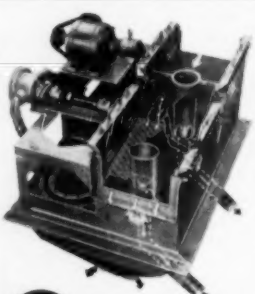
New Building Plans Discussed at Meeting

For several years there has been discussion about securing a new building to house the societies now occupying the Engineering Societies Building in New York. Space in this building is inadequate and its facilities outmoded, it being 47 years old. No definite conclusion has yet been reached about a new building but present activity indicates that a definite proposal will be offered the Founder Societies before the end of the year. Within three to five years a new building may be ready for occupancy.

Preliminary plans are for a new building with 180,000 sq ft of usable floor space, compared with 118,000 in the present building. Additional societies can then be accommodated. About $2 million is available from anticipated sale of the present building and accumulated reserves of United Engineering Trustees that could be utilized for the purpose. A new site might cost $1.5 million, possibly much less. Something on the order of $6 million for the entire new building project is envisaged.

Though the preference is for a building in mid-town New York, headquarters in other cities will also be considered. An active project for an engineering center in Pittsburgh is under way and a definite proposal is expected shortly. It is hoped that the land required for the new building may take the form of a gift, and that possibly a substantial part of the money required for the entire project may be raised by contributions. An expression of opinion as to the best location for a new building is invited from AIME members.

June 16 was the date of the first dinner-meeting of the Bisbee-Douglas Subsection, at the Warren District Country Club, Naco, Ariz. Seated from left to right are W. J. Uren, Warren T. Smith, C. R. Kuzell, and E. H. Torgensen, Subsection Chairman.



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Mexico Beckons At Regional Meeting

"Let's take a walk to Old Mexico," will probably be heard more than once during the AIME Regional Meeting October 28 to November 2, to be held at El Paso during the city's annual International Mining Days celebration.

Whether by foot, private car, or even trolley, Mexico will rank high on the list of sights and things to do, when not attending technical sessions or field trips. One field trip will be to the Carlsbad Caverns at Carlsbad, N. M., and the potash mines in the area on the following day.

Industrial Minerals papers are in the process of being scheduled but it's already known that John Allen will present *Bentonite in McKinley County*, while two others will deal with new developments in the Carlsbad area and industrial minerals of the Navajo area of Arizona.

The El Paso Chamber of Commerce sponsors International Mining Days, and this year a record crowd is predicted. Mining men from all over the U. S., Mexico, and Canada are expected to attend. The Hotel Paso Del Norte will be AIME headquarters but accommodations of various types are available. Members should contact T. R. Lind, Chairman, Hotel and Housing Committee, International Mining Days, '53, Chamber of Commerce, 310 San Francisco Street, El Paso, Texas.

One of the side trips planned for the El Paso Regional Meeting will be to the Carlsbad Caverns. Included in the jaunt is a visit to the Carlsbad potash mines. Other side trips are being planned for the meeting to be held during International Mining Days.

Among the things members are advised to bring along, if they are so inclined, are tennis racquets, golf clubs, swimming trunks, fishing rods, or just a mood to relax. El Paso weather is said to be favorable to sports, sightseeing, or just taking it easy. The Chamber of Commerce just about guarantees lots of sunshine.

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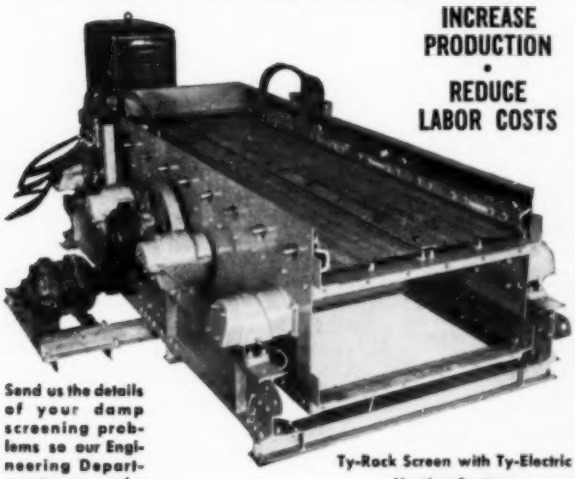

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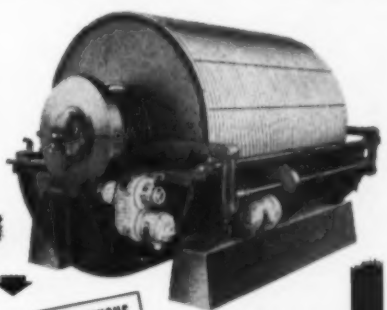

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Personals

G. Don Emigh, formerly production manager for Monsanto Chemical Co., Soda Springs, Idaho, has been appointed director of mining for Monsanto's Phosphate Div. and will have his headquarters in St. Louis.

Philip D. Pearson, superintendent of Menominee Range Operations, Inland Steel Co., Iron River, Mich., is now manager of Inland's subsidiary, Caland Ore Co., Steep Rock, Ont.

C. DeWitt Smith is now in the New York office of St. Joseph Lead Co. He was formerly superintendent of mines for St. Joseph Lead Co. in Balmat, New York.

Raymond Garcia-Loera is with Cananea Consolidated Copper Co., Sonora, Mexico.

THEODORE MARVIN

Theodore Marvin is president of the Michigan Chemical Corp., St. Louis, Mich. Mr. Marvin was formerly director of advertising for Hercules Powder Co., Wilmington, Dela. This position is now held by **Montgomery R. Budd**. Mr. Budd joined Hercules in 1929 as associate editor of *The Explosives Engineer*.

Charles R. Kennedy, formerly with Reynolds Alloys Co. in Alabama, is serving with the army at Fort Leonard Wood, Mo.

Harlowe Hardinge, president of Hardinge Co. Inc., York, Pa., has announced the election, by the board of directors, of **John J. Cadot** as executive vice president and **Robert J. Russell** as vice president in charge of sales. Mr. Cadot will continue as treasurer and works manager and Mr. Russell will remain corporation secretary and sales manager.

E. E. N. Smith is now with Ownamin Ltd. in Toronto. He was with Eldorado Mining and Refining Ltd. in Saskatchewan.

Ed C. Newton, Jr. is now employed as practice engineer in the Coal Mine Works of the Tennessee Coal and Iron Div., U. S. Steel Corp., Fairfield, Ala.

Irving C. Falk, who was formerly with Bethlehem Cornwall Corp., Pa., is now with Edwards, Kelcey & Beck, Newark, N. J.

Judson C. Travis has been elected president of Handy & Harmon, New York, N. Y.

Earl S. Mollard has been promoted to general manager of mining and smelting operations for M. A. Hanna Co. in Oregon. He was assistant general manager of Minnesota operations. This position is now held by **B. M. Andreas.**

B. M. Crouse has returned to Canada and is with Consolidated Discovery Yellowknife Mines, N. W. T. He was in Western Australia with the Australian Blue Asbestos Co.

R. B. Fuller has been made vice president in charge of the Phosphate Div. of International Minerals & Chemicals. **F. B. Bowen** is now manager of the Florida Phosphate Div. and **C. Lester Richards** is manager of the Tennessee Phosphate Div.

H. F. Brownbill is general manager of Frontino Gold Mines Ltd., OTU, via Medellin, Colombia. He will be there two years.

E. L. Beutner, Ishpeming, Mich., resident geologist for the Michigan Ore div. of Jones & Laughlin Steel Corp., is now assistant chief geologist.

Rodney D. Chipp, director of engineering for Du Mont Television Network, was elected president of the Technical Societies Council of New York. **J. V. N. Dorr,** chairman of the board of the Dorr Co., was elected vice president.

W. Arthur Wall has accepted the position of mill superintendent with United Keno Hill Mining Co. Ltd. at Elsa, Yukon Territory. Mr. Wall was formerly mill superintendent for Cariboo Gold Quartz Mining Co. Ltd., Wells, B. C.

R. H. Clayton is now with Mufulira Copper Co. Ltd., Northern Rhodesia. He was with A. S. & R. Co., Chihuahua, Mexico.

Nathan Landau has left Stonehaven Mine and is with Finalist Mine, Chakari, Southern Rhodesia.

Jack H. Eisaman, formerly an open hearth superintendent at South Works of U. S. Steel Co., has accepted the position of midwest sales representative for International Graphite and Electrode Div., Speer Carbon Co.

James L. Lane is with Kaiser Bauxite Co., St. Ann, Jamaica, B.W.I. as a civil engineer.

TRUMAN H. KUHN

Truman H. Kuhn, professor of mining geology at Colorado School of Mines, has been appointed dean of the college's graduate division. He will succeed **Clark B. Carpenter** who retires from the faculty this summer. Also retiring this summer is **F. M. Van Tuyl,** head of the Department of Geology. He will be succeeded by **L. W. LeRoy.**

William B. Mather, chairman of the Minerals Technology Dept. at Southwest Research Institute, San Antonio, Tex., has just returned from Brazil where he spent ten weeks on an Institute project studying the pegmatites of Brazil.

Patrick H. O'Neill has resigned as dredge superintendent in the Fairbanks Department of the United States Smelting, Refining and Mining Co. He has left Alaska to be chief engineer for Cia. Minera Choco Pacifico, Cali, Colombia.

Richard S. Newlin has been advanced to the presidency of Inspiration Copper Co. to succeed the late **William D. Thornton,** former president (See OBITUARIES, p. 832). Mr. Newlin is also vice president of Anaconda Copper Mining Co. in charge of mining operations.

George R. Rogers has resigned as geophysical engineer for Phelps Dodge Corp. to accept a similar position with Bear Creek Mining Co. He is stationed at the Rocky Mountain District Office, 1219 California Street, Denver.

Hubertus van Arkel is plant manager of Surinaamsche Bauxite Mij., Moengo, Surinam.

L. K. Wilson, geologist for American Smelting and Refining Co., is now at the San Francisco office of the company. **Kenyon Richard** has been named to succeed Mr. Wilson in the southwest office at Tucson, Ariz.

George F. Leaming is now with Braden Copper Co., Rancagua, Chile.

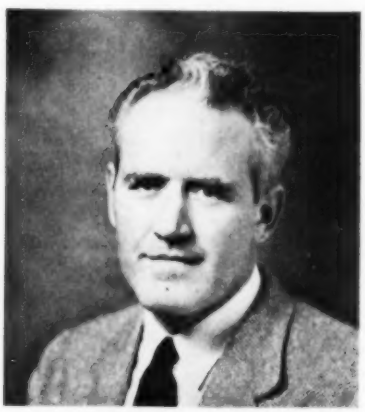
Sydney Nashner has been appointed technical assistant to **Eldon L. Brown,** president of Sherritt Gordon Mines Ltd., Toronto.

W. J. O'Connor is president and general manager of Independent Coal & Coke Co., Salt Lake City.

Edward J. Perry has left Falconbridge Nickel Mines Ltd. for a position with Giant Yellowknife Gold Mines Ltd., Northwest Territories.

James A. Rolls is now employed as a chemical engineer, technical supervisor by B. F. Goodrich Chemical Co. in Institute, W. Va.

Rodney B. Sprague has left England and is now in Toronto with Asarco Exploration Co. of Canada Ltd.



MICHAEL J. GLEASON

Robert D. Longyear, president of E. J. Longyear Co., Minneapolis, has announced the appointment of **Michael J. Gleason** as manager of the company's Contract Drilling Div. Mr. Gleason succeeds **Vincent N. Burnhart** who becomes assistant general manager.

Ronald Naftal is now living in Lander, Wyo. He is employed as plant superintendent by the Wyoming Mica & Metals Corp.

A. W. Estey is with Tara Exploration and Development, Uranium City, Saskatchewan.

H. R. Gault has accepted appointment as Executive Secretary, Div. of Earth Sciences, National Research Council, Washington, D. C.. He is on leave of absence from Lehigh University where he is a professor of geology.

Charles K. McArthur, Jr. is now employed by the American Cyanamid Co., Grand Junction, Colo. He was with Cleveland-Cliffs Iron Co., Taconite, Minn.

Arnold S. Bunte, of Roswell, N. M., has been appointed associate professor of geology at the Colorado School of Mines for the 1953-54 academic year. Mr. Bunte is currently division manager of the Permian Basin for Vickers Petroleum Co. He graduated from Colorado School of Mines in 1926 with a geological engineering degree.

Frank X. Gilg has been appointed an executive assistant in the Boiler Division of The Babcock & Wilcox Co., New York. In May Mr. Gilg was the leader of the U. S. delegation of boiler manufacturers and engineers attending the international conference in Paris to develop an international boiler code.

James B. Colson is chief geologist for the Sunshine Mining Co., Kellogg, Idaho.

Ronald J. Morton is manager of research for Oliver Iron Mining Div. of U. S. Steel Corp. Mr. Morton, formerly concentration engineer, will be responsible for Oliver's research and development work on taconite and low-grade ore concentration. Born in England, he studied mining and metallurgy at Birmingham University on a scholarship won while a mechanical engineering apprentice. Before joining Oliver in Duluth in 1945, Mr. Morton worked for mining companies in Burma and Canada.

Abe Kreitman is engineering geologist with the Institute of Industrial Research, Syracuse University, N. Y.

Jo K. Crosby is geophysical engineer with Newmont Exploration Ltd., Jerome, Ariz.

E. Willard Berry, professor and chairman of the Geology Department of Duke University, is with Companhia de Diamantes de Angola doing a geological survey of diamond fields. His address is Diamang, Tshikapa, Belgian Congo, via Leopoldville. Mr. Berry expects to be back at Duke University Sept. 18.

Andrew Allan, Jr. has accepted a position with Manu-Mine Research & Development Co., Reading, Pa. He was formerly with the U. S. Bureau of Mines in Schuylkill Haven, Pa.

Oscar S. Straus has been elected president of the Theodore Roosevelt Association to fill out the term of Major General **Frank R. McCoy** who resigned because of ill health. Mr. Straus is treasurer of American Smelting and Refining Co. and director of Revere Copper and Brass.

Thomas L. Kesler, who was with U. S. Steel Co. in Tennessee, has joined Foote Mineral Co. as company geologist. Mr. Kesler's first assignment will be at Foote's King Mountain Mining Div.

GEORGE H. DEIKE, JR.

J. T. Ryan, Jr., recently elected president of Mine Safety Appliances Co., Pittsburgh, has announced the election of **George H. Deike, Jr.** as vice president. Mr. Deike is also director and treasurer of Mine Safety Appliances Co. of Canada.

Leon E. Charlot is with Benguet Consolidated Mining Co. in the Philippine Islands.

Robert M. Dreyer has resigned as professor of geology at the University of Kansas to join the exploration staff of Kaiser Aluminum and Chemical Corp., Oakland, Calif.

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Obituaries

Clarence E. Abbott (Member 1904) died April 14, 1953. He was a civil engineer and vice president of the Tennessee Coal, Iron and R. R. Co. Mr. Abbott began with this company in 1906 as chief engineer of iron mines and quarries. Born in Kendall, Wis., he received his B.S. degree in 1901 from the University of Wisconsin, and after working as a rodman, transitman, and assistant mining engineer, his C.E. degree in 1905. He was at one time superintendent for the Vinegar Hill Zinc Mine Co. in Wisconsin and the Elking Lead and Zinc Co. in Missouri. The author of numerous technical papers, Mr. Abbott contributed to the methods of mining hematite ores in Alabama and to the development of mechanical loaders.

R. Leslie Beattie died June 10, 1953. Mr. Beattie was vice president and general manager of Canadian operations of The International Nickel Co. of Canada Ltd. He was born on a farm near Caledonia, Ont., and in 1911 joined the Canadian Copper Co., a predecessor of International Nickel. During World War I he served for three years with the Royal Canadian Engineers and received the Military Medal. In World War II under his personal direction the International Nickel wartime expansion program was started and achieved in record time.

Appreciation of
John A. Burgess
by John D. Burgess

John A. Burgess, mining engineer and geologist, died May 22 in Berkeley, Calif., eight days before reaching the age of 77 years. Mr. Burgess, known to his contemporaries as "Jack," was a gold miner who loved a good mine and could make a good mine live up to its owners' hopes.

Jack was born in Nova Scotia, graduated from the University of California in 1906 and immediately entered the mining profession with the Tonopah Mining Co., in Tonopah, Nev., a proving ground for many men who later proved themselves to be of the highest order. From 1911 to 1920, Jack was successively general superintendent and general manager for The Nevada Wonder Mining Co., and the United Eastern Mine, both of which were notable for rewarding their owners handsomely. For the next 13 years he maintained offices in the Mills Building in San Francisco, and traveled the United States, Alaska, Canada, Mexico, and South America widely as a consulting engineer and geologist. During this time he was recognized for his sound approach to problems, and also for his humor and interest in surrounding country and people. From 1933 to 1943 he was general manager of the Carson Hill Gold Mining Corp., which profitably handled low grade ore.

He was a member of the AIME, Mining and Metallurgical Society of America, Sigma Xi, and was always a staunch Republican. He was a contributor to *Economic Geology, Mining and Scientific Press,* and other mining publications.

A good husband and father, he was always an inveterate fisherman and rifleman. He enjoyed his just rewards for the last ten years of his life living in Sonora, Calif., where he engaged primarily in pursuit of the wily trout, even though remaining quite active professionally. Whether we knew him as father, friend, miner, or fisherman, many of us will miss having Jack around.

Norman C. Prudent (Member 1950) died. Mr. Prudent was mine superintendent for Southwest Potash Corp., Carlsbad, N. Mex. He was born in Centralia, Ill., and first worked in mines repairing electrical equipment. He worked for 14 years for Crescent Mining Co., Peoria, Ill., beginning as safety engineer, leaving as general superintendent. He was also general superintendent for Hanna Coal Co., St. Clairsville, Ohio.

Robert C. Ried (Member 1936) died Mar. 27, 1953. Well known in the cement industry, Mr. Ried was owner of the New York firm of R. C. Ried, Engineers. At the age of 16 he worked as a draftsman for Valley Forge Cement Co., West Conshohocken, Pa., and while employed there studied and graduated from Villanova College in 1934. After a period in California and Argentina designing and operating flotation plants, Mr. Ried returned to Valley Forge Cement Co. to become superintendent. Before starting his own firm, Mr. Ried was consulting engineer and senior partner with Knowles Associates.

Henry St. John Somerset (Member 1905) died Sept. 30, 1952. Mr. Somerset was general manager of the Electrolytic Zinc Co. of Australasia Ltd. in Melbourne, Australia. He was born in Brisbane and attended grammar school there. After working for two years under an analytical chemist, Mr. Somerset in 1893 joined Mount Morgan Gold Mining Co., later becoming chief assayer. For many years he was general superintendent for Broken Hills Associated Smelters in Port Pirie.

Appreciation of
William D. Thornton

William D. Thornton, a member of AIME since 1896, passed away in New York City on June 9, 1953. A native of Montana, he was born in Deer Lodge on April 22, 1870 and attended schools in Butte and later Columbia University.

Mr. Thornton, a pioneer of the copper industry, was actively interested in mining during his entire life, and in his early years he owned and operated various claims in Montana and northern Mexico. He was closely associated with the history and operations of Anaconda Copper Mining Co. and for many years served as a director of that company and of several of its subsidiaries. Among his other interests was the Thornton Hotel, one of Butte's most famous, which he built in 1902 and operated for many years. The building is now occupied by the Anaconda Employees' Club. Mr. Thornton was also one of the original directors of the Montana Power Co.

During the last 40 years Mr. Thornton was active in the management of both Greene Cananea Copper Co. and of Inspiration Consolidated Copper Co. He was among the first who recognized Cananea as a great copper mining district and he aided in the consolidation of the numerous small companies in the area. Mr. Thornton was elected president and a director of Greene Cananea Copper Co. on Oct. 26, 1916 and held these offices until his death. Mr. Thornton was also closely associated with Inspiration Consolidated Copper Co. from the date of its incorporation on Dec. 18, 1911. He was a member of its board of directors from its inception and served as its vice president until 1927 when he became president. He held this office at his death.

Even though for the past 35 years he made his home in New York, Mr. Thornton would return each summer to his lodge in West Yellowstone and would indulge in his great love—

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fishing the waters of the Madison. His fishing exploits, together with those of his life-long companions, became a part of Butte's extraordinary legend.

"Will" Thornton was a man of great simplicity and human understanding. Those who knew him are not likely to forget his friendly smile, his quiet humor, his courtesy and grace of manner. His vision was broad but he never lost sight of the dignity of the individual nor the charm of a kindly word.

Appreciation of
John Weldon Wilson
by J. D. Harlan

John Weldon Wilson, mining engineer, affectionately known as "Weary," suddenly passed out of a busy, useful, and happy life on February 26 at his home in Las Vegas, Nev., at age only 64.

To the business world he was better known as a banker and a distributor of Shell oil products; to friends and associates dating back 40 years or longer Weary was beloved for his fine character, genial nature, and loyalty to his profession, largely as prospector in spare time throughout a successful business career.

Probably few will now remember a high school graduate high on a bleak slope of Mt. Baldy in New Mexico in 1911 "single-jacking" a tunnel in hard porphyry, batching in a log cabin, but still finding the time and energy to walk over the mountain to E-town or Red River for an occasional ball game and dance, then making the long climb back in time to "get in the round." The objective of the tunnel was a downward extension of a silver-bearing contact, long since worked out and abandoned. Had old workings been accessible they would have revealed that the ore measure bottomed on a normal fault dipping into the mountain and would have saved Weary two years of hard labor.

Then realizing that a successful prospector needs at least a working knowledge of the habits of orebodies and faults he worked in mines in the Mogollons for money with which to finance a course at the School of Mines in El Paso. A mine accident, resulting in a broken leg, postponed entry at the school and World War I further interrupted study but with the energy and courage of a born prospector he completed his schooling in 1919.

He worked for West End Chemical, first in Latin America and, from 1921 to 1928, as superintendent of a borax mine tributary to Las Vegas. Notwithstanding a lucrative business career in Las Vegas which began in 1928 Weary continued as local agent of West End Chemical throughout the remaining 25 years of his life and also remained active in mining, prospecting, and grubstaking prospectors, principally in the Goodsprings district. After he knew that his heart was not ticking reliably his only concession to the infirmity was to buy a truck equipped for prospecting trips, including an air mattress to replace the Indian blanket in which customarily he rolled up under the stars.

Modest by nature he was nevertheless proud of having his father-in-law, Lloyd C. Douglas, dedicate his last great novel, *The Big Fisherman*, to him. Lastly he was keenly pleased to collaborate with his wife, Betty, and her sister, Virginia, in writing the highly entertaining story of their father in a recent book, *The Shape of Sunday*.

Almost as if Weary sensed that his days were nearing the end he and Betty attended the recent Institute meetings at the Statler principally for the pleasure of greeting old friends. A week later he died. May his happy soul find good prospecting in the unknown realm of infinite formations.

NECROLOGY

Date Elected	Name	Date of Death
1936	John A. Burgess	May 22, 1953
1924	H. C. Forney	June 18, 1953
1944	O. C. Garst	May 25, 1953
1907	Frederick G. Lasier	Unknown
1905	Robert H. Stewart	December 1952
1896	W. D. Thornton	June 9, 1953
1927	John W. Wilson	Feb. 26, 1953

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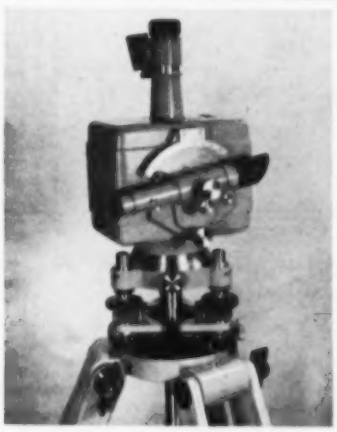

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

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Hibbing—Sermon, Milton R. (M)
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Tennessee
Copperhill—Ramsey, J. R. (R. C/S—S-J)
Ducktown—Goodman, James E. (R. C/S—S-M)
Jefferson City—Luttrell, Eugene M. (J)

Utah
Keetley—Scott, Roger K. (R. C/S—S-J)

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Ontario, Ottawa—Bennett, William J. (M)

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Coming Events

Aug. 31-Sept. 2, Minerals Beneficiation Division, Hibbing, Minn.

Sept. 7-11, Conference of Representatives from the Engineering Societies of Western Europe and the United States of America, Paris.

Sept. 8-13, Joint Meeting Industrial Minerals Division, AIME, Keltic Lodge, Ingonish, Nova Scotia.

Sept. 11, AIME, St. Louis Lead Belt Meeting, Tour of St. Joseph Mines and Mills, St. Louis.

Sept. 13-16, Electrochemical Chemical Society Inc., Ocean Terrace Hotel, Wrightsville Beach, N. C.

Sept. 21, ASME, Industrial Instruments and Regulators Div., and **Instrument Society of America,** exhibit and joint conference, Sherman Hotel, Chicago.

Sept. 21-24, American Mining Congress Mineral Mining Convention, Olympic Hotel, Seattle.

Oct. 1-2, AIME, Regional Meeting, Pacific Petroleum Chapter, Ambassador Hotel, Los Angeles.

Oct. 6, AIME, National Open Hearth Steel Committee, Buffalo Section.

Oct. 7, AIME, National Open Hearth Steel Committee, Chicago Section, Phil Smidt's.

Oct. 7-9, National Assn. of Consulting Engineers, south central region, Mayo Hotel, Tulsa, Okla.

Oct. 8-9, Ninth National Conference on Industrial Hydraulics, Hotel Sheraton, Chicago.

Oct. 9, AIME, St. Louis Local Section, St. Louis University, St. Louis.

Oct. 9, AIME, National Open Hearth Steel Committee, Eastern Section, Fall Meeting, Warwick Hotel, Philadelphia.

Oct. 15-17, AIME, Second Annual Clay Minerals Meeting, University of Missouri, Columbia, Mo.

Oct. 15-17, AIME National Open Hearth Steel Committee, Southwestern Section, Fall Meeting, Baker Hotel, Dallas.

Oct. 18-21, AIME, Petroleum Branch Fall Meeting, Baker and Adolphus Hotels, Dallas.

Oct. 19-21, AIME, Institute of Metals Division, Fall Meeting, Hotel Allerton, Cleveland.

Oct. 19-23, Forty-first National Safety Congress and Exposition. Sessions on industrial safety, Conrad Hilton, Congress, Morrison, and Hamilton Hotels, Chicago.

Oct. 22, AIME, St. Louis Local Section, Engineers Club of St. Louis and ASCE, Engineers Club, St. Louis.

Oct. 27, Assn. of Consulting Chemists & Chemical Engineers, 25th Anniversary Annual Meeting, Hotel Belmont Plaza, New York.

Oct. 28-31, AIME, El Paso Meeting, in cooperation with International Mining Days, Hotel Paso Del Norte, El Paso.

Oct. 29-30, AIME, ASME Fuels Conference, Conrad Hilton Hotel, Chicago.

Oct. 29-31, Annual Meeting of National Council of State Board of Engineering Examiners, Plaza Hotel, San Antonio.

Oct. 30-31, AIME, National Open Hearth Steel Committee, Deshler-Wallick, Columbus.

Nov. 6, AIME, National Open Hearth Steel Committee, Pittsburgh Section, William Penn Hotel, Pittsburgh.

Nov. 13, AIME, St. Louis Section, Coal Meeting, York Hotel, St. Louis.

Nov. 29-Dec. 4, ASME, Annual Meeting, Statler Hotel, New York.

Dec. 2-4, Electric Furnace Steel Conference, Netherland Plaza Hotel, Cincinnati.

Dec. 11, AIME, St. Louis Section, York Hotel, St. Louis.

Dec. 13-16, American Institute of Chemical Engineers, Annual Meeting, Hotel Jefferson, St. Louis.

Dec. 28-29, Annual Chemical Engineering Symposium, University of Michigan, Ann Arbor.

Feb. 15-18, 1954, AIME Annual Meeting, Hotel Statler, New York.

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180° F mixture against 152-ft head

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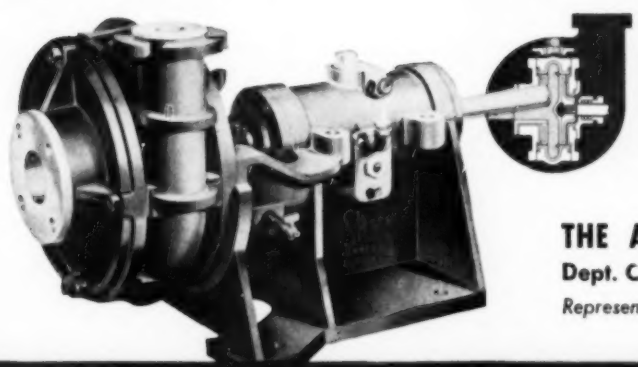
Through 3700 ft of 8-in pipe

Large zinc concentration plant in Mexico, showing tailings dam in right foreground. Tailings are delivered by two Hydroseal Slurry Pumps (one acting as standby) at an average rate of 760 to 1025 G.P.M. through 3700 feet of 8 inch pipe. Both pumps are equipped with automatic speed controls to compensate for changes in volume and/or head.



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